COMPLETE PREVIEW OF NATIONAL MEETING—p. 11-A

Forest Products Journal

Frank H. Kaufert to Become FPRS Eleventh President at National Meeting in Buffalo—See p. 23-A

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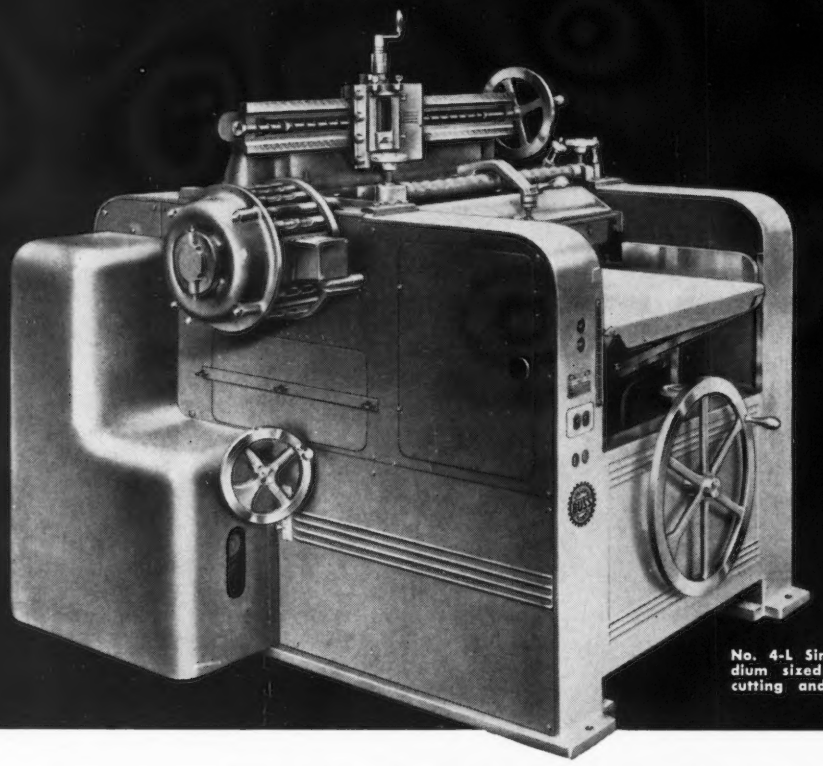

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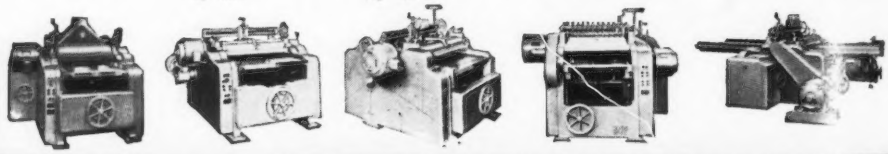

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FOREST PRODUCTS JOURNAL

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IMPORTANT FPRS DATES

June 24–28: Eleventh National Meeting, Hotel Statler, Buffalo, N. Y.

August: Upper Mississippi Valley Section Meeting, International Falls, Minn.

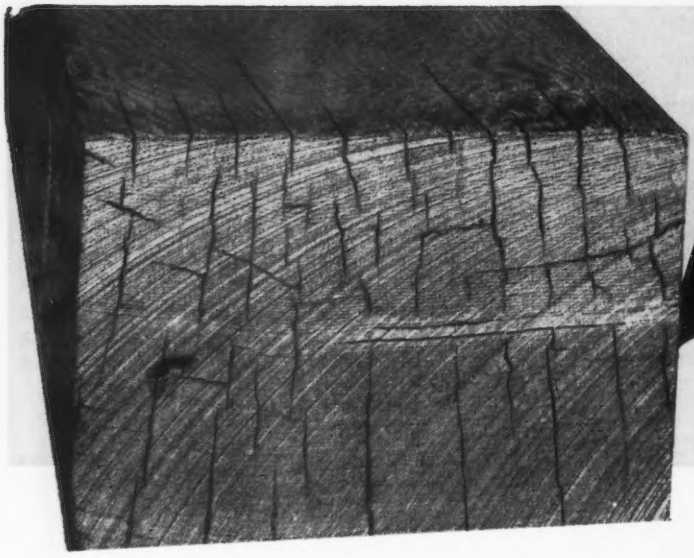
Fall 1957: Carolinas – Chesapeake Section Annual Meeting, Roanoke, Va.

Sept. 1957: Inland Empire Section Meeting, Omak, Wash.

Oct. 21–22: Mid-South Section Meeting, Crossett, Ark.

Oct. 31–Nov. 1: Northeast Section Meeting, New York City

June 22–26, 1958: Twelfth National Meeting, Madison, Wis.



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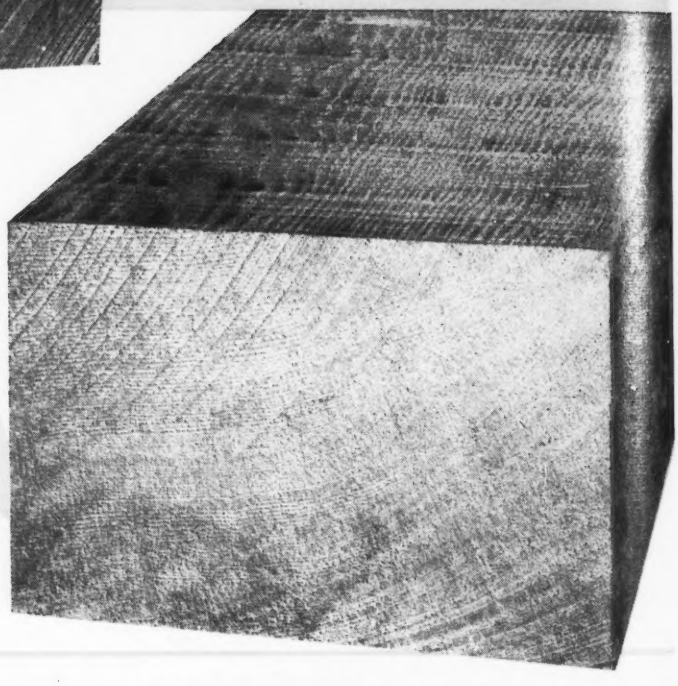

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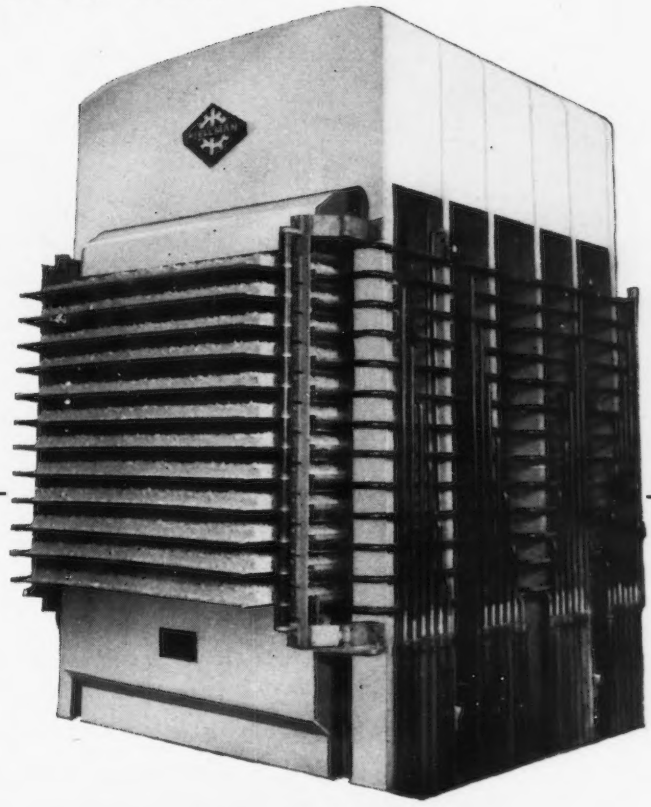

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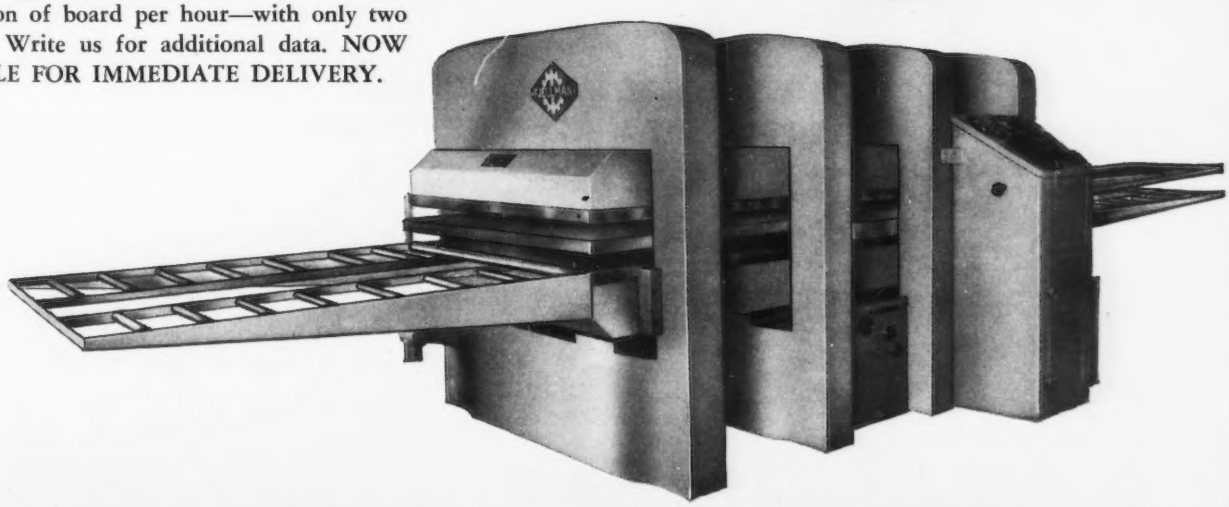

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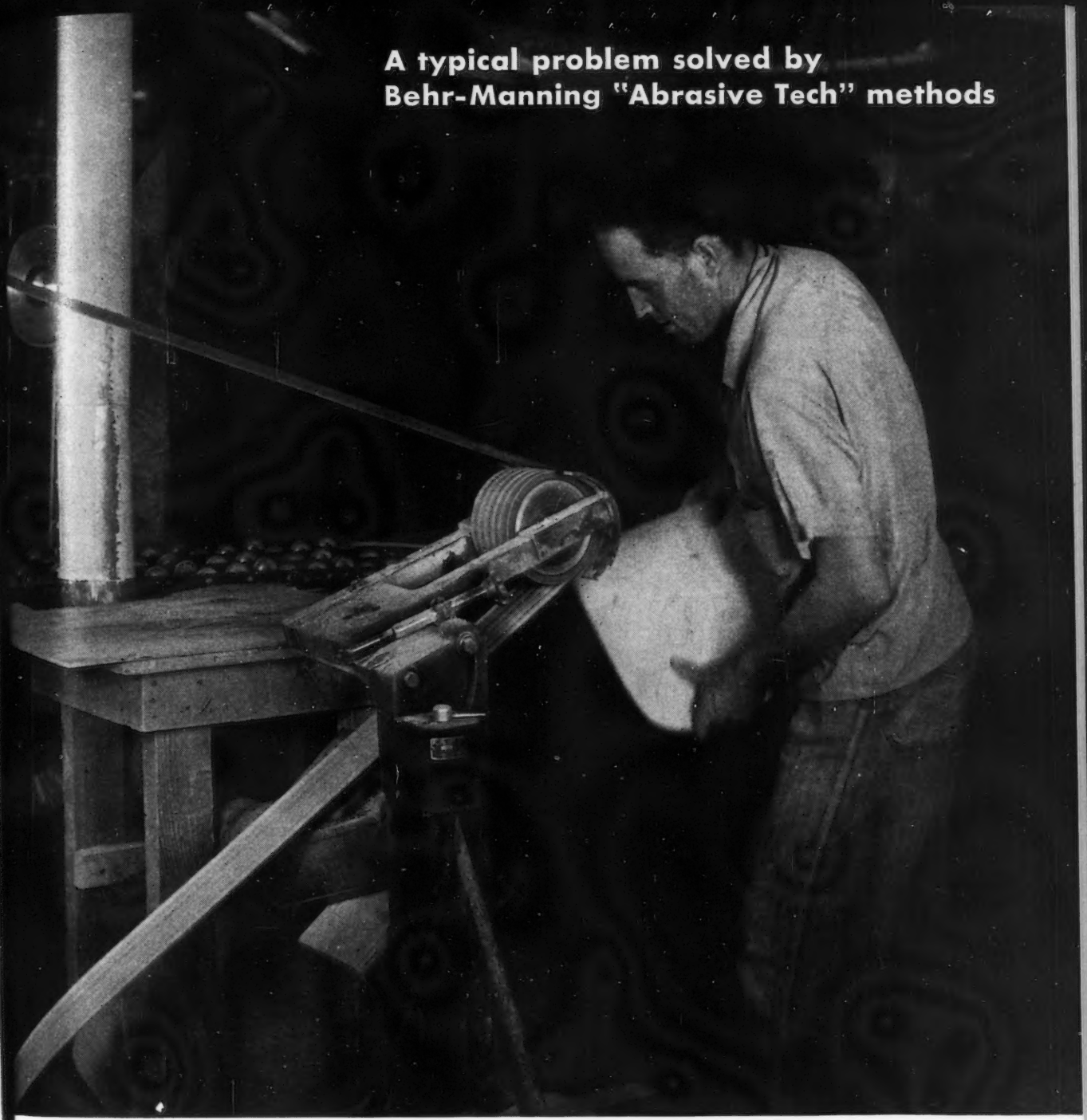

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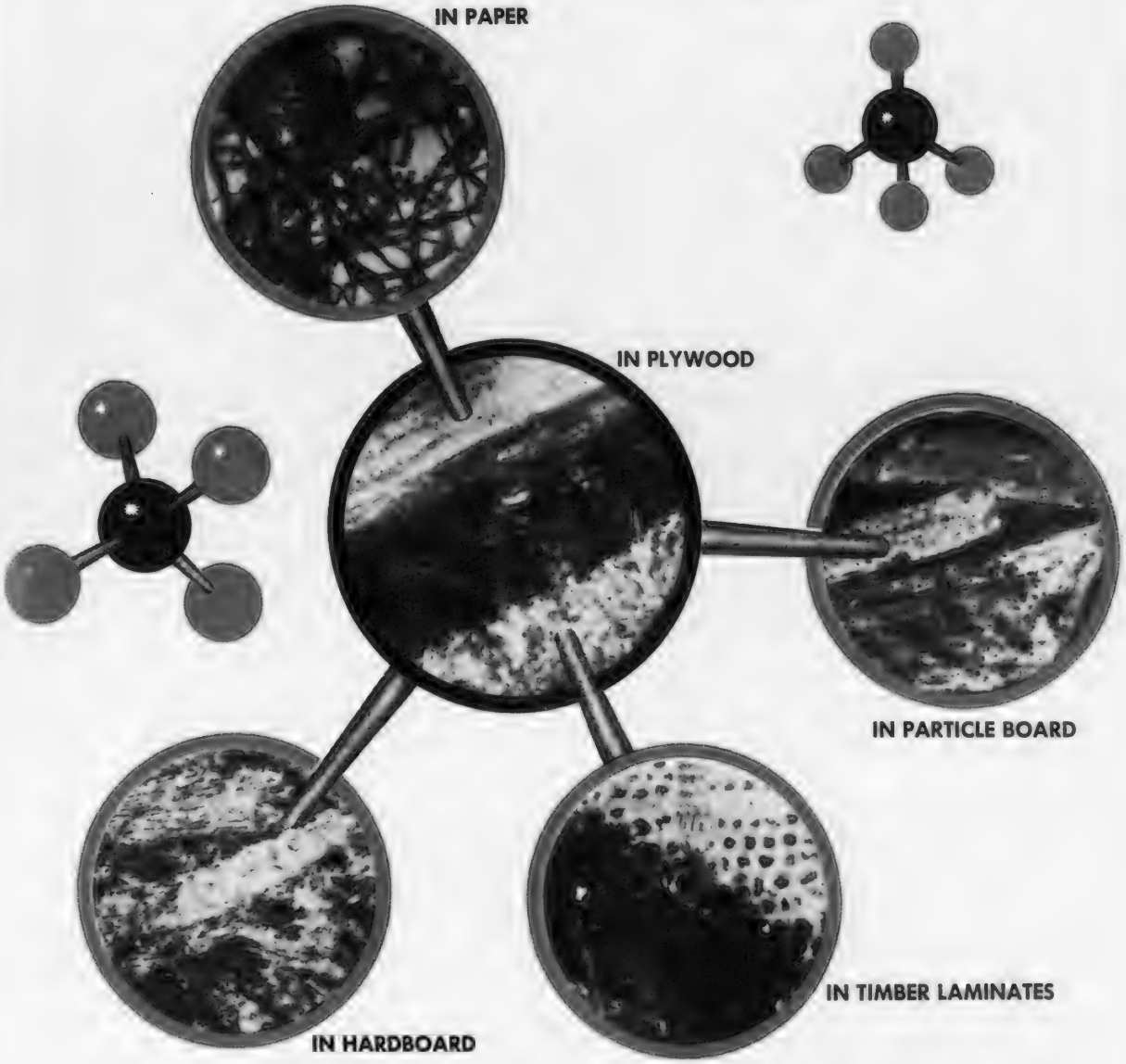

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FPRS NEWS-DIGEST

Volume VII MAY, 1957 Number 5

ADVANCE PLANS INDICATE OUTSTANDING FPRS NATIONAL MEETING IN BUFFALO

Eleventh National Meeting Features 12 Technical Sessions and 70-Booth Suppliers Exhibit

Buffalo, known as the City of Good Neighbors, will be the scene of the FPRS Eleventh National Meeting June 23–28. Located at the eastern end of Lake Erie, the Buffalo area is endowed by nature with unsurpassed wonders and the city is also a booming industrial giant.

The 1957 FPRS Convention City is also called the gateway to picturesque Canada, with the Peace Bridge connecting Buffalo and Fort Erie, Ontario. This magnificent bridge spanning the Niagara River is the largest single point of entry into Canada.

The most famous tourist attraction in the area is awe-inspiring Niagara Falls. FPRS registrants and their families will have an opportunity to see the Falls at night when they are guests of industry suppliers for the Paul Bunyan Smorgasbord and Falls Tour.

Advance registration for the meeting indicates a turnout of more than 600 persons will attend the sessions and the Wood Industry and Suppliers Exhibit, according to General Chairman Charles R. Lockard. Twelve technical sessions with more than 50 papers and panel discussions have been scheduled on every phase of wood research and development. Registrants will also have an opportunity to attend problem clinics and discussion meetings of FPRS 14 subject matter divisions.

View of downtown Buffalo, showing City Hall in center foreground. Hotel Statler is three-wing building at left.

Materials and services available to the wood industry will be displayed by more than 60 firms at the 70-booth Wood Industry and Suppliers Exhibit to be held in conjunction with the meeting. The exhibit, to be open daily throughout the meeting, will be located on the mezzanine floor of the Hotel Statler, adjacent to meeting rooms.

Registration Hours

Meeting headquarters will be in the 1100-room Hotel Statler, centrally located in downtown Buffalo. Registration desks on the mezzanine floor will be staffed from 1 to 5 p.m. Sunday, June 23; 9 a.m. to 6 p.m. Monday, June 24; 8:30 a.m. to 5 p.m. Tuesday, June 25; and 8:30 a.m. to 12:30 p.m. Wednesday and Thursday, June 26 and 27.

The registration fee is $8 for FPRS members, $12 for non-members, and includes admission to all technical sessions, committee meetings, plant tours, and the Paul Bunyan Smorgasbord and Tour, as well as a copy of abstracts of technical papers. Ladies registration fee is $5.

The National Executive Board and Northeast Section Board have scheduled meetings Sunday afternoon, June 23. In addition, meetings will be held of the National Employment, Industry–Education, Publications, and Membership Committees.

C. R. LOCKARD
General Chairman

F. H. KAUFERT
Program Chairman

Headquarters for FPRS' 11th National Meeting will be the Hotel Statler, Buffalo

Registrants will be guests of the Host Section (Northeast) and Cooperating Section (Eastern Canadian) at a get-together reception Sunday evening.

Fourteen subject matter divisions of the Society have scheduled problem clinics and meetings Monday morning, June 24. Meeting from 8:30 to 10:30 a.m. will be the Logging, Chemical Utilization, Machining, Quality Control, Glues and Gluing, Drying, and Packaging Divisions. From 10:30 a.m. to 12:30 p.m., the following divisions will meet: Lumber Manufacture, Wood Preservation, Finishing, Veneer and Plywood, Composition Board, Marketing, and Industry–Education.

General Opening Session

The technical program will officially begin with the General Opening Session Monday afternoon, June 24. Registrants will be welcomed by Buffalo's Mayor Steven Pankow and Northeast Section Chairman D. K. Saunders. A synopsis of the technical program will be given by General Chairman Lockard.

Principal addresses at the General Session will be given by FPRS President Ralph H. Bescher and Lincoln R. Thiesmeyer, President, Pulp and Paper Research Institute of Canada, Montreal. Speaking on "Everything, Including The Smell," Dr. Thiesmeyer will emphasize current research and development aimed at complete utilization of forests.

R. H. BESCHER

L. R. THIESMEYER

Dr. Thiesmeyer was trained professionally as a geologist and for some 14 years was engaged in college teaching and research. During World War II he was head technical aide in the Office of Scientific Research and Development in Washington. He then served as executive assistant to the director of Brookhaven National Laboratory from 1946 to 1950. Having a continuing close interest in peaceful applications of atomic energy, Dr. Thiesmeyer is a director of Isotope Products Ltd. and a sponsor of courses on Atomic Energy for Management being given in the U. S. under the auspices of the National Industrial Conference Board.

Other features of the General Session will be presentation of Northeast Section Student Awards by Chairman

General Chairman Lockard (center) discusses meeting plans with R. C. Deckert, Exhibit chairman, and F. E. Carlson, chairman of radio and television arrangements.

Saunders; Vance Publishing Co. "Wood" awards by J. F. Koellisch, editor and manager of Wood and Wood Products magazine; and Hitchcock Publishing Co. "Award of Merit" citations by V. C. Hogren, vice-president.

Concluding the opening session will be the National Business Meeting when the gavel of the presidency will be turned over to incoming President Frank H. Kaufert by Mr. Bescher. Other new officers will be introduced, committee and business reports given, and Society business conducted.

Monday evening, past presidents of the Society will have a dinner and the Section Officers' Advisory Committee will meet under the chairmanship of Joe Allegretti, Midwest Section Chairman. Other registrants will be "on their own on the town," with a list of suggested activities to be provided.

The technical sessions will begin Tuesday, June 25, with the following half-day sessions scheduled: Tuesday: Glues and Gluing, Machining, Veneer and Plywood, Finishing; Wednesday: Logging, Composition Board, Wood Preservation; Thursday: Lignin Utilization, Drying, Lumber Manufacture, Chemical Utilization, and Quality Control.

Official Luncheon and Banquet

"The Challenge of Forest Products Research" will be discussed by Fred C. Foy, President of Koppers Co., Inc., Pittsburgh, Pa., principal speaker at the Official Luncheon Tuesday noon, June 25. The traditional FPRS Official Banquet will be held that evening, with dinner, door prizes, and a variety

F. C. FOY

of entertainment. A Barber Shop Choral Group will be featured on the program.

On Wednesday, June 26, men's tours have been scheduled to plants of Carborundum Co., Niagara Falls; Upson Co., Lockport, N. Y.; Kittinger Co., Buffalo; and Rudolph Wurlitzer Co., N. Tonawanda, N. Y. Many other plants within a 200-mile radius of Buffalo have scheduled open house on Friday, June 28, following the formal meeting. There will also be opportunity to visit the new $4 million wood products laboratory at the College of Forestry, Syracuse.

Refreshment hours en route to the Paul Bunyan Smorgasbord in Brock Monument Park, Ontario, will be at 5 p.m. Wednesday. Men will meet at Hotel Niagara, Niagara Falls, N. Y., and the ladies and children will stop at the Hotel Sheraton–Brock, Niagara Falls, Ont. The entire group will then enjoy the smorgasbord supper being sponsored by industry suppliers and visit Niagara Falls before returning to Buffalo.

Besides the technical sessions on Thursday, June 27, luncheon meetings will be held of Section Officers' Advisory Committee—Executive Board, Division Chairmen, and various organization groups. The Northeast Section will hold a business meeting in the afternoon and a party will be given for press representatives.

There will be an informally conducted employment service throughout the meeting, with Chairman Newell Norton and members of his committee available for interviews. The service is both for employers seeking personnel and men looking for new positions.

Outstanding Ladies Program

A well-rounded entertainment program is in store for ladies and children attending the meeting. A get-acquainted Kaffee Klatsch is scheduled Monday morning, June 24. The ladies are invited to the Official Luncheon and Official Banquet on Tuesday June 25, and a Ladies Tea and "Sunrise" is planned that afternoon. During the banquet, the children will have a box supper picnic at the famed Buffalo Zoo.

A shopping tour of Niagara Falls, Ont., is being arranged for Wednesday afternoon, following which the ladies and children will stop at Hotel Sheraton–Brock, Niagara Falls, Ont., for refreshments before joining the men at the Paul Bunyan Smorgasbord. Final event on the ladies program will be a tour of the General Mills plant in Buffalo Thursday afternoon June 27. Betty Crocker will personally conduct the tour and describe processes used in making cake mixes, frostings, flour, and cereals.

Official Technical Program

Forest Products Research Society Eleventh National Meeting

June 23–28, 1957 **Buffalo, N. Y.**

Session I—Glues and Gluing

9:00 a.m. Tuesday, June 25. Chairman: Alan A. Marra, University of Michigan, Ann Arbor, Mich. Vice-Chairman: R. F. Blomquist, U.S. Forest Products Lab, Madison, Wis.

"Dielectric Properties of Resin Glues for Wood"—T. J. S. Cole and D. G. Miller, Forest Products Laboratories of Canada, Ottawa, Ont.

"End Gluing of Lumber"—D. B. Richards, Alabama Polytechnic Institute, Auburn, Ala.

"Better Utilization of Wood Thru Gluing"—Panel Discussion. Panel includes: Moderator: R. F. Blomquist; C. D. Dosker, Gamble Bros., Inc., Louisville, Ky.; Willard J. Worth, National Homes Corp., Lafayette, Ind.; John Reno, Pacific Lumber Co., Chicago, Ill.; and John D. Ritchie, Douglas Fir Plywood Assoc., Tacoma, Wash.

Session II—Wood Machining

9:00 a.m. Tuesday, June 25. Chairman: L. A. Patronsky. Vice-Chairman: Norman C. Bye, Disston Div., H. K. Porter Co., Philadelphia, Pa.

"Carbide Tool Technology"—T. C. Weill, Metallurgical Products Dept., General Electric Co., Detroit, Mich.

(Title to be announced)—Norman C. Franz, University of Michigan, Ann Arbor, Mich.

"Machining of Particle Board"—E. M. Davis, U. S. Forest Products Lab, Madison, Wis.

"Modern Methods for Modern Woodworking" — Clifford Baker, Minnesota Mining and Manufacturing Co., St. Paul, Minn.

"Wide Belt Sanding of Wood Now a Fact" — Panel Discussion. Moderator: P. F. DeSaix, Carborundum Co., High Point, N. C. Panel includes: C. A. Baker, Minnesota Mining and Manufacturing Co., St. Paul, Minn.; L. G. Brown, Curtis Division of Carborundum Co., Jamestown, N. Y.; representative of J. M. Nash Co., Milwaukee, Wis.; and representative of Behr-Manning Co., Troy, N. Y.

Session III—Veneer and Plywood

2:45 p.m. Tuesday, June 25. Chairman: H. O. Fleischer, U. S. Forest Products Lab, Madison, Wis. Vice-Chairman: John Butler, Hardwood Plywood Institute, Atlanta, Ga.

"Plywood Imports and Their Effect upon U. S. Plywood Producers"—Harry Fidler, Owens-Illinois Plywood Co., North Troy, Vt.

"Development of a Highly Accelerated Test for Water-Resistant Hardwood Plywood"—C. A. Hart, N. C. State College, Raleigh, N. C.

"New Plywood Manufacturing Equipment"—E. D. Cottrell, Setter Bros., Inc., Cattaraugus, N. Y.

Session IV—Wood Finishing

2:45 p.m. Tuesday, June 25. Chairman: F. H. Thomas, Sherwin-Williams Co., Chicago, Ill. Vice-Chairman: D. G. Lubeck, Hammond Organ Co., Chicago, Ill. Moderator: C. F. Van Epps, Stromberg-Carlson Co., Rochester, N. Y.

"New Aspects in Paint Blistering"—D. F. Laughnan, U. S. Forest Products Laboratory, Madison, Wis.

"Blister and Stain Resistant Paints"—W. G. Vannoy, E. I. duPont de Nemours & Co., Wilmington, Del.

"Exposure Characteristics of Clear Finishes for Exterior Wood Surfaces"—Golden Gate Paint and Varnish Production Club, Neil Estrada, Reichhold Chemicals, Inc., South San Francisco, Calif.

"Wood Fillers"—P. A. Blachman, Glidden Co., Reading, Pa.

"Color Control in Furniture Finishing"—W. E. Martin, Grand Rapids Varnish Corp., Grand Rapids, Mich.

Session V—Logging

9:30 a.m. Wednesday, June 26 Chairman: F. C. Simmons, Northeastern Forest Experiment Station, Upper Darby, Pa. Vice-Chairman: Paul M. Dunn, St. Regis Paper Co., New York, N. Y. Moderator: W. R. Warner, Southern Lumber Co., Warren, Ark.

Lobby of Hotel Statler, headquarters for FPRS Eleventh National Meeting.

"Attaining Greater Logging Safety"—E. H. Reeves, Ontario Lumbermen's Safety Assoc., Toronto, Ont.

"Developments Leading Toward a Better Power Chain Saw"—James Conroy, Chain Saw Age, Portland, Ore.

"Harvesting Hardwood Logging Residues"—Leland Hooker, Michigan College of Mining and Technology, Houghton, Mich.

"Tree-Length Wheeled Skidding"—D. W. Gray, K. V. P. Co., Ltd., Espanola, Ont.

"Integrated Hardwood Logging"—J. C. Noblet, Calumet & Hecla Co., Calumet, Mich.

Session VI—Wood Composition Board

9:30 a.m. Wednesday, June 26. Chairman: George G. Marra, Washington State Institute of Technology, Pullman, Wash. Vice-Chairman: J. R. Roberts, Weyerhaeuser Timber Co., Longview, Wash. Moderator: David McCalla, Fiberesin Plastics, Inc., Oconomowoc, Wis.

"Particle Board and the Geneva Conference"—Wayne C. Lewis, U. S. Forest Products Lab, Madison, Wis.

"An Analysis of the Panel Products Field"—E. M. Williston, Weyerhaeuser Timber Co., Longview, Wash.

"What's your Question on Particle Board"—Panel Discussion. Panel includes: J. R. Roberts, Quizmaster; J. R. Ash, Monsanto Chemical Co., Seattle, Wash.; A. L. Mottet, Long-Bell Division, International Paper Co., Longview, Wash.; William Drees, Formica Co., Cincinnati; H. C. L. Miller, Miller-Hofft, Inc., Richmond, Va.; J. M. Crafton, Chipcraft Corp., Morristown, Tenn.

Session VII—Wood Preservation

9:30 a.m. Wednesday, June 26. Chairman: Ira Hatfield, Wood Treating Chemicals Co., St. Louis, Mo. Vice-Chairman: C. S. Walters, University of Illinois, Urbana, Ill.

"Effects of Soil, Moisture, and Aeration Variables in Bioassay by the Soil Block Culture Method"—S. S. Sakornbut and R. J. Balske, Monsanto Chemical Co., St. Louis, Mo.

"Factors Affecting the Soaking

Treatment of Basswood at Low Temperatures"—C. S. Walters.

"How to Build Better Frame Homes"—C. Miles Burpee, American Wood Preservers Institute, Chicago, Ill.

"Pentachlorophenol and Heavy Petroleum for the Preservative Treatment of Railway Cross-Ties"—G. E. Olson, F. J. Meyer, and R. M. Gooch, Dow Chemical Co., Midland, Mich.

Session VIII—Chemical Utilization (Lignin)

9:00 a.m. Thursday, June 27. Chairman: E. G. Locke, U. S. Forest Products Lab, Madison, Wis. Vice-Chairman: A. S. Gregory, Weyerhaeuser Timber Co., Longview, Wash. Moderator: Walter F. Holzer, Crown Zellerbach Corp., San Francisco, Calif.

"Chemical Utilization of Lignin"—I. A. Pearl, Institute of Paper Chemistry, Appleton, Wis.

"Separation and Properties of Hemicellulose, Cellulose and Hydrogenated Lignin from Sawdust"—Conrad M. Schuerch, State University of New York College of Forestry, Syracuse, N. Y.

"The Lignin Dimethyl Sulfide Process"—W. M. Hearon, Crown Zellerbach Corp., Camas, Wash.

"Activated Carbon from Spent Pulp Liquor"—J. W. Hassler, West Virginia Pulp and Paper Co., Tyrone, Pa.

"Upgrading Spent Sulphite Liquor by Sugar Removal"—G. A. Dubey, L. A. Boggs, Philip Luner, and A. J. Wiley, Sulphite Pulp Manufacturers' Research League, Appleton, Wis.

Session IX—Wood Drying

9:00 a.m. Thursday, June 27. Chairman: L. D. Espenas, Oregon Forest Products Laboratory, Corvallis, Ore. Vice-Chairman: S. B. Preston, University of Michigan, Ann Arbor, Mich.

"Mechanical Properties of Red Oak Related to Drying"

"Kiln Drying of Southern Hardwood Cross-Ties"—J. B. Huffman, University of Florida, Gainesville, Fla.

"Variation in Moisture Content of Air-Seasoned Southern Pine Lumber"—R. M. Carter, N. C. State College, Raleigh, N. C.; and Rufus H. Page, Forest Utilization Service, U.S.F.S., Macon, Ga.

"Factors Affecting the Cost of Hardwood Drying"—Edwin Conway, Lumber Drying Specialties, Grand Rapids, Mich.

"Stacking, Stickers, and Related Problems"—Panel Discussion. Panel includes: Ray C. Rietz, Moderator, U. S. Forest Products Lab, Madison, Wis.; Hereford Garland, Michigan College of Mining and Technology, Houghton, Mich.; Percy Deverick, Kent Coffee Manufacturing Corp., Lenoir, N. C.; F. W. Cook, Moore Dry Kiln Co., Portland, Ore. Material prepared by Mr. Cook will be presented by F. E. Dickinson, California Forest Products Lab, Richmond, Calif.

Session X—Lumber Manufacturing

9:00 a.m. Thursday, June 27. Chairman: Milton H. Mater, Mater Machine Works, Corvallis, Ore.; Vice-Chairman: E. P. Ivory, Ivory Pine Co., Dinuba, Calif.

"Quality Control in the Sawmill"—Charles M. Kreider and Marvin W. Coats, Brooks–Scanlon, Inc., Bend, Ore.

"Dimensional Quality Control in a North Central Hardwood and Softwood Sawmill"—D. N. MacRae, Connor Lumber & Land Co., Laona, Wis.

"Effect of Various Types of Equipment on Sawing Accuracy in Eastern Canadian Hardwoods and Softwoods"—G. Brodie Gillies, Gillies Bros. & Co., Ltd., Braeside, Ont.

"Can Lumber Compete?"—J. S. Bethel and A. C. Barefoot, Jr., N. C. State College, Raleigh, N. C.

"Power Requirements for Log Carriage Setworks"—Milton H. Mater, Mater Machine Works, Inc., Corvallis, Ore. (To be presented by title only)

Session XI—Chemical Utilization (General)

2:00 p.m. Thursday, June 27. Chairman: E. G. Locke, U. S. Forest Products Lab, Madison, Wis.; Vice-Chairman and Moderator: A. S. Gregory, Weyerhaeuser Timber Co., Longview, Wash.

"Recent Advancements in Pine Gum Chemistry"—E. L. Patton and J. C. Braun, Naval Stores Station, Southern Utilization Research Branch, U. S. Dept. of Agriculture, Olustee, Fla.

"Structure and Composition of Aspen Bark"—R. L. Hossfeld and F. H. Kaufert, School of Forestry, University of Minnesota, St. Paul, Minn.

"Extraneous Components of Western Red Cedar"—J. A. F. Gardner and G. M. Barton, Forest Products Laboratories of Canada, Vancouver.

"Chemical Properties, Derivatives and Uses of Levulinic Acid"—Carl Bordenca, Heyden Newport Chemical Corp., New York, N. Y.

"Charcoal Production in Kilns"—Edward Beglinger, U. S. Forest Products Lab, Madison, Wis.

Session XII—Quality Control

2:00 p.m. Thursday, June 27. Chairman: Charles Latimer, Nickey Bros., Memphis, Tenn. Vice-Chairman: R. C. Calahan, Singer Sewing Machine Co., Clydebank, Scotland

"Quality Control Pays Off in Woodwork"—Robert Chateauneuf, Singer Manufacturing Co., St. Johns, P. Q.

"A Statistical Quality Control Program"—Vincent R. Ross, Draper Corp., Swannanoa, N. C.

(Title to be announced)—John Saunders, A. G. Spalding & Bros., Inc., Chicopee, Mass.

Fifteen Students Submit Wood Award Entries

Fifteen students from eight colleges and universities have entered the 1957 Wood Award Competition, A. J. Panshin, chairman of the FPRS Industry-Education Division, and J. L. Koellisch, manager and editor of WOOD AND WOOD PRODUCTS magazine, sponsors of the awards, have announced.

Two cash awards and certificates will be given for the best papers based on research conducted by graduate students. The first place winner will receive $350 and will be invited to present his paper at the 11th National Meeting in Buffalo. The second place winner will receive $150.

Students from the following schools are entered in the contest: University of Michigan, Yale University, University of British Columbia, University of Toronto, Iowa State College, State University of New York College of Forestry, Duke University, and University of Washington.

Titles of papers include: Shrinkage Failures of Wood as Influenced by Temperature and Moisture Content; Mechanical Properties of Red Oak Related to Drying; Distribution of Leucoanthocyanin and Taxifolin in a Douglas-fir Tree; Strength of Glued Timber Lap Joints; Strength Properties of Tension Wood and Normal Wood of Eastern Cottonwood Using Cross-Lap and Block Shear Test Specimens; Preservative Tolerances in a Group of Wood-Destroying Fungi; An Accelerated Wood Preservative Termite Study; The Relation of Wood Properties and Nosebar Pressure in Production of Veneer; Quantifying the Topography of Wood Surfaces; Some Contributions Towards a Knowledge of Spiral Grain in Second Growth Douglas-fir and Western Hemlock; A Comparison of Four Methods Evaluating Interior Mahogany Plywood Made on the West Coast; Effect of Temperature on the Electrical Resistance of Wood at Several Moisture Contents; Creep and Other Strain Behavior of Wood in Tension Parallel to the Grain; The Sorption of Water Vapor by Domestic and Tropical Woods; and Some Properties of Commercial Particle Boards.

FPRS Eleventh National Meeting

Timetable of Events

June 23–28, 1957
Buffalo, N. Y.

Time	SUNDAY, JUNE 23	MONDAY, JUNE 24	TUESDAY, JUNE 25	WEDNESDAY, JUNE 26	THURSDAY, JUNE 27
7:30 a.m.			Authors Breakfasts—Technical Sessions I, II, III, IV	Authors Breakfasts—Technical Sessions V, VI, VII	Authors Breakfasts Technical Sessions VIII, IX, X, XI, XII
8:00-10:30 a.m.		Employment Service			
8:30 a.m.-12:30 p.m.		Division Meetings and Problem Clinics 8:30-10:30—Logging, Chemical Utilization, Machining, Quality Control, Glues and Gluing, Drying, Packaging; 10:30-12:30—Lumber Manufacture, Preservation, Finishing, Veneer and Plywood, Composition Board, Marketing, Industry-Education		Registration—Mezzanine	Registration Mezzanine
8:30 a.m.-5:00 p.m.			Registration Mezzanine		
9:00-11:30 a.m.			Technical Sessions: I. Glues and Gluing II. Machining	Employment Service	Technical Sessions: VIII. Lignin Utilization, IX. Drying X. Lumber Manufacture
9:00 a.m.-6:00 p.m.		Registration—Mezzanine	Suppliers Exhibit	Suppliers Exhibit	Suppliers Exhibit
9:00 a.m.-9:00 p.m.		Suppliers Exhibit			
9:30 a.m.-12:00 noon				Technical Sessions: V. Logging, VI. Composition Board, VII. Preservation	
10:00-11:30 a.m.		Press Conference; Ladies Kaffee Klatsch			
12:00-1:30 p.m.					Section Officers' Luncheon; Division Chairmen's Luncheon; Organization luncheons
12:30-2:30 p.m.			Official Luncheon		
1:00-5:00 p.m.	Registration—Mezzanine			Ladies and Children's Tour to Niagara Falls, Ont.	
1:15-5:00 p.m.		General Opening Session		Men's Plant Tours	
2:00-4:00 p.m.					Ladies Tour of General Mills Plant; Employment Service
2:00-4:30 p.m.					Technical Sessions: XI. Chemical Utilization, XII. Quality Control
2:30-4:30 p.m.			Ladies Tea and Surprise		
2:30-5:30 p.m.			Employment Service		
2:45-4:45 p.m.			Technical Sessions: III. Veneer and Plywood, IV. Finishing		
3:00 p.m.	Executive Board Meeting; Northeast Section Board Meeting				Press Party
4:00-5:00 p.m.					Northeast Section Business Meeting
5:00 p.m.			Children's Zoo Picnic	Refreshment Hour—Men, Hotel Niagara; Ladies, Hotel Sheraton Brock	
5:30-8:00 p.m.	National Committee Meetings				
6:30 p.m.		Past Presidents' Dinner		Paul Bunyan Smorgasbord and Night Tour of Niagara Falls	
7:00-9:00 p.m.	Reception Maple Leaf Room	Section Officers' Meeting	Official Banquet		

FRIDAY, JUNE 28—Individual tours of plants holding open house; trip to Wood Products Laboratory at College of Forestry, Syracuse; historical tours

MORE THAN 150 PERSONS CONTRIBUTING TO SUCCESS OF FPRS NATIONAL MEETING

Meet some of the authors, session chairmen, and committee members who are contributing time and effort toward the success of FPRS Eleventh National Meeting. Latest technical advances in the wood industry will be reported in 12 technical sessions, with more than 50 papers and panel discussions scheduled. Meetings of 14 Subject Matter Divisions will also be open to all registrants. Representative displays of raw materials and equipment will be shown in the 70-booth Suppliers Exhibit.

J. R. ASH

C. L. BABCOCK

C. A. BAKER

R. J. BALSKE

A. C. BAREFOOT

G. M. B[illegible]ON

A. G. BATTAGLIA

E. BEGLINGER

H. L. BENNETT

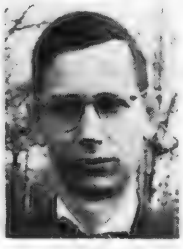
J. S. BETHEL

R. F. BLOMQUIST

C. BORDE[illegible]CA

J. C. BRAUN

C. M. BURPEE


J. L. BUTLER

N. C. BYE

F. E. CARLSON

R. M. CA[illegible]ER

R. CHATEAUNEUF

M. W. COATS

T. J. S. COLE

J. J. CONROY

E. M. CONWAY

L. E. CUM[illegible]G

E. M. DAVIS

H. S. DAVIS

R. C. DECKERT

P. F. DeSAIX

P. F. DEVERICK

F. E. DICKI[illegible]N

J. EASON

L. D. ESPENAS

N. S. ESTRADA

G. B. FAHLSTROM

W. V. FICHTEL

H. C. FIDLER

H. O. FLEISCHER

N. C. FRANZ

J. A. F. GARDNER

H. GARLAND

R. C. GILL

G. B. GILLIES

R. M. GOOCH

P. H. GRAHAM

D. W. GRAY

A. S. GREGORY

C. A. HART

I. HATFIELD

W. M HEARON

F. K. HENRICH

W. F. HOLZER

L. W. HOOKER

A. T. HOWSE

J. B. HUFFMAN

E. P. IVORY

C. M. KREIDER

E. D. LACKEY

C. LATIMER

D. F. LAUGHNAN

W. C. LEWIS

. G. LOCKE

D. G. LUBECK

D. N. MacRAE

A. A. MARRA

G. G. MARRA

W. E. MARTIN

M. H. MATER

D. McCALLA

F. J. MEYER

D. G. MILLER

H. C. L. MILLER

A. L. MOT

J. C. NOBLET

N. A. NORTON

R. H. PAGE

A. J. PANSHIN

F. T. PARRISH

L. A. PATRO KY

E. L. PATTON

R. D. PAULEY

I. A. PEARL

W. F. PFEIL

S. B. PRESTON

E. H. REEV

D. B. RICHARDS

R. C. RIETZ

J. D. RITCHIE

J. R. ROBERTS

V. R. ROSS

S. S. SAKORN UT

D. K. SAUNDERS

M. E. SCHLEICHER

C. M. SCHUERCH

F. C. SIMMONS

F. H. THOMAS

C. F. VanEP

W. G. VANNOY

C. S. WALTERS

W. R. WARNER

T. C. WEILL

E. M. WILLISTON

R. L. YOUNG

SUPPLIERS TO EXHIBIT PRODUCTS AND SERVICES

Displays Will Feature Scale Models of New Equipment and Woodworking Materials

More than 60 companies and educational institutions have reserved space in the 70-booth Wood Industry and Suppliers Exhibit to be held in connection with the Eleventh National Meeting June 23–28 in Buffalo, according to Exhibit Chairman Russell C. Deckert.

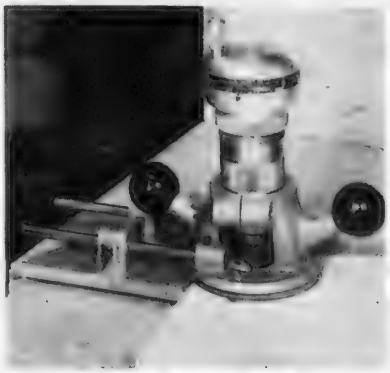
Products and services of industry suppliers will be displayed on the mezzanine floor of the Hotel Statler, meeting headquarters, adjacent to rooms where principal technical sessions will be held. Scale models of new equipment, literature, photos, movies, and slides will be featured in many of the exhibits.

The following list indicates booth assignments, exhibiting firms, principal products, and company representatives:

1. **Senco Products, Inc., Cincinnati, Ohio.** Display and demonstration of staplers and tackers, featuring models using low carbon staples. A 16 mm. film will be shown in a separate suite, showing staplers in use under actual production conditions. William Tillinghast, vice-president and sales manager, Cincinnati; Leo Bernstein, sales, Pittsburgh; Irving Goodlerner and Charles Landy, sales, Eastern New York; Bert Iaia, sales, Rochester, N. Y.; Jack Armacost, sales manager, Chicago; Art Rickling, sales manager, Detroit; and John Price, sales manager, Cleveland, Ohio

Staplers and tackers will be shown by Senco Products, Inc.

Onsrud Machine Works, Inc., Chicago, Ill. Heavy production woodworking machinery, small portable air tools, air turbine routers, router bits, and cutters. R. M. Miller, vice-president and sales manager, Woodworking Machinery Division; A. M. Johnson, sales manager, Onsrud Cutter Manufacturing Co., A. J. Ewan, sales service engineer, Onsrud Machine Works

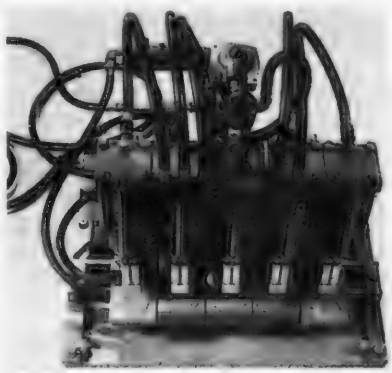


Onsrud portable router

3. **Peter Cooper Corps., Gowanda, N. Y.** Applications of animal, liquid animal, and resin adhesives. R. C. Gill, technical representative, Gowanda; G. W. Grace, Western sales manager, Chicago; G. P. Nonweiler, sales representative, Indianapolis; W. W. Haslett, sales representative, Richmond, Va.; and H. F. Zahn, sales representative, Buffalo

4. **Industron Corp., Newton Highlands, Mass.** High frequency heating equipment. Paul D. Zottu, president

5 & 6. **Masonite Corp., Chicago.** Five types of industrial hardboard products: perforated, presealed, and laminated hardboards; examples of hollow core panel construction; and display of various finishes applied to Masonite Presdwoods. Various types of perforated Presdwood will be exhibited, as well as variety of curves into which 1/10-inch Presdwood may be bent. Production specialists E. R. Graebner, O. R. Braun, Joe Hahn, Lee Rodda, R. H. Fisher, G. H. Montgomery, R. J. Nelson, W. A. Stumpf



Fastener Corp. multiple head air-operated bench tacker

7. **Bauer Bros. Co., Springfield, Ohio.** Model of "Bauer-bale" system of preparing pulp for shipment, including "fluff-dry" treatment of pulp and baling it. D. L. Michel, advertising manager

8 & 9. **International Harvester, Chicago.** Logging equipment. W. R. Swanson.

10. **Fastener Corp., Chicago.** Automatic tackers, staplers and staples. New air-operated bench tacker is manufactured in single units with range of stapling heads which can be used, depending upon size staple to be driven. Single units can be combined into multiple units, depending upon requirements of particular job. O. William Powers, national sales manager; Appleton Fryer, manager of Buffalo office; Fowler Glave, manager of Syracuse office

11. **Timber Engineering Co., Washington, D. C.** Display panels showing roof test, pilot plant particle board production, bending jig, chemical drying, ladder test, end and edge jointing. R. C. Cranch, assistant to director of research, and other staff members

12. **Mattison–Greenlee Service Corp., Rockford, Ill.** Photos and literature on woodworking machinery and tools manufactured by Mattison Machine Works and Greenlee Bros. & Co. P. L. Mattison, vice-president, and W. C. Hagstrom, advertising manager, Mattison Machine Works; K. White and J. A. Lengquist, Greenlee Bros. & Co.

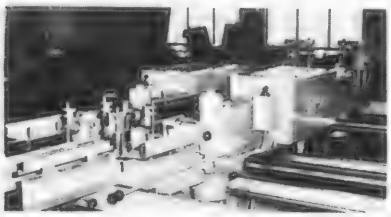
Mattison model 276 moulder

13. **Reichhold Chemicals, Inc., White Plains, N. Y.** Adhesives and resins. W. Buchanan, supervisor, technical service.

14. **Dryalator Division, Orr & Sembower, Inc., Reading, Pa.** Wood drying systems. R. C. Gray, manager

15. **Production Development Co., Inc., Raleigh, N. C.** Johnson platen-type particle board process. Uses two-opening shuttle loading hot plate press and can produce splinter, shaving, or flake particles in single or multi-layer boards. IMA Klessman continuous feed veneer edge banding

Particle board made by Johnson platen-type process (above). IMA Klessman continuous feed veneer edge banding and trimming machine (below)



and trimming machine which automatically feeds edge veneer strips from either or both sides. As panels leave machine, oversize veneer is automatically trimmed by four fine-tooth saws which compensate for thickness variations and warping. E. A. Shook and Mrs. A. H. Johnson

16. S. H. Smith Co., Indianapolis. Woodworker & Veneers and Plywood magazines. J. F. Burrell, general manager and editor

21. Hitchcock Publishing Co., Wheaton, Ill. Wood Working Digest magazine. Miss E. McDaniel, editor

22. Miller–Hofft, Inc., Richmond, Va. Model particle board plant. R. C. Seavers, John O'Brien, Roy H. Sides, and H. C. L. Miller.

23. Adamson United Co., Akron, Ohio. Particle board extrusion machine. G. S. Andrus, engineer, Adamson United; representatives of Lane Co., Altavista, Va.

24. Wel-Dri Co., Memphis, Tenn. Bulletins and photos of custom-made dry kilns. W. L. Wellford, Jr., president

25. Power Line Sales, Inc., Detroit. Air staplers, including new AR series featuring air return principle which utilizes supply of compressed air to drive staple and return piston after staple has been driven. Staplers are especially suited for cabinet work, assembling drawers, case backs on furniture, sash and door work, and similar woodworking operations. Harold Dickinson, Rochester, N. Y.; Frank Laidlaw, Emerson, N. Y.; and Bruce McIntyre, Memphis, Tenn.

26. Deluxe Saw and Tool Co., Louisville, Ky. Carbide-tipped cutting tools and sawblades. A. G. Feldmann, vice-president, engineering; N. C. Campbell, Midwest district manager; C. W. Tittsler, Southern Atlantic district manager

27. Bahnson Co., Winston Salem, N. C. Type E humidifier, manufactured in two models with capacity up to three gallons of water per hour, used extensively for laboratories, storage areas, and rooms with low ceiling heights. Illustrated literature on complete line of industrial

Bahnson Type E humidifier

humidification equipment—Types H and L centrifugal humidifiers, Type ESC pneumatic atomizers, Types BA–1 and BA–2 saturated air humidifiers, Type SBA steam humidifiers. J. C. Rose, agency sales manager; Frank Russ, A. R. Kamman Co., Buffalo; W. L. Jacobs, Ballston Lake, N. Y.; W. H. Stell, Rochester

28 & 29. National Starch Products, Inc., New York. Adhesives, Granite Board, gluing systems. James Dillon, vice-president; A. G. Battaglia, manager; John Meany, Eastern sales

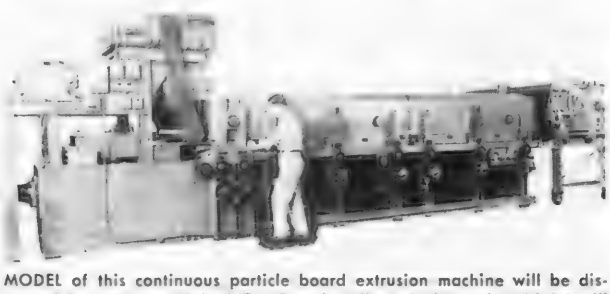
Installing General Electric solid cemented carbide planer knife

supervisor; James Elf, Midwest sales supervisor; and P. H. McCorkick, field engineer, all of Structural Products Division

30. Standard Dry Kiln Co., Indianapolis. Dry kilns. R. H. Elliott, vice-president

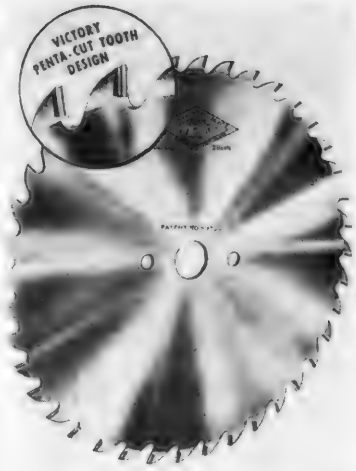
31. General Electric Co., Metallurgical Products Dept., Detroit, Mich. Solid cemented carbide planer knives produced in lengths up to 72 inches by new process. K. R. Beardslee, general manager; G. M. Hadley, manager, marketing; F. J. Stanoba, manager, cutting tool sales; J. W. Mason, manager, advertising and sales promotion; T. C. Weill, woodworking sales engineer; B. R. Best, advertising and sales promotion specialist; T. W. Trendowski, design engineer; J. DeEulis, manager, press relations; A. M. Thomson, manager, East Central district; B. B. Grey, woodworking sales representative

32. The Heil Co., Milwaukee, Wis. Copy and illustrations of equipment for dehydrating wide variety of wood by-products, ranging from sawdust, chips, flakes, to rather coarsely-hogged veneer waste. Light duty machine, Model SD75-22 dryer, will handle from 1,000 to 5,000 dry pounds per hour. Intermediate heavy duty dryer is recommended for loads from 3,000 to 10,000 dry pounds per hour. Large industrial dryer will handle from 8,000 to 20,000 pounds per hour. All machines provide three-stage drying in a single drum, with all particles uniformly dried. K. F. Johnson, advertising dep



MODEL of this continuous particle board extrusion machine will be displayed by Adamson United Co. Complete line of air staplers (right) will be shown by Power-Line Sales, Inc.

Here's a Handy Guide to Exhibits



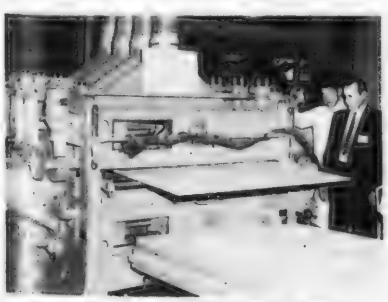
Victory carbide-tipped Penta-Cut saw

33. Victory Carbide Saw & Tool Co., Inc., Chicago. Circular saws, groovers, dados, form cutters, router bits; solid carbide planer, moulder, and jointer knives. First showing of carbide-tipped Penta-Cut saw for cutting aluminum, magnesium, copper, and other non-ferrous metals. C. W. Vanderwerker, Sr., president; and H. I. Ross, sales promotion and advertising

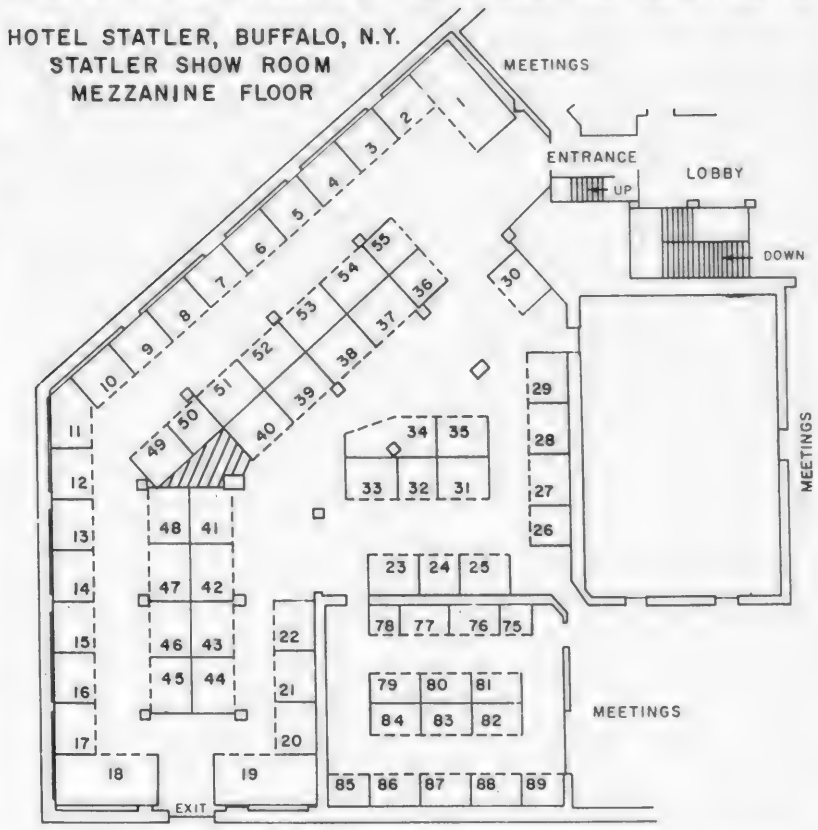
34 & 35. Perkins Glue Co., Landsdale, Pa. Resin, casein and vegetable glues. J. H. Stryker, F. J. Buss, J. B. Hayward, V. D. Marshall, J. A. Barnes, L. E. Clark, Jr., Perkins Glue Co.; J. B. Stryker, Jr. and R. C. Stock, Perkins Glue Co. of Canada, Ltd.

36 & 55. Kennametal, Inc., Latrobe, Pa. Carbide bits, knives, tips, etc.; variety of materials machined by carbide. Rex V. Reynolds, manager, and D. A. Curtis, engineer, woodworking sales

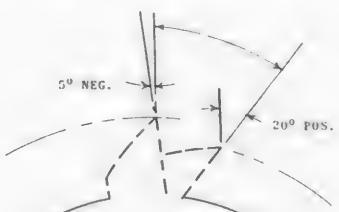
37 & 38. Yates–American Machine Co., Beloit, Wis. Applications of double deck sanders for surfacing particle board and production of hardwood flooring with use of flooring matchers will be among illustrations of woodworking machinery. J-line of machinery, used in school shops and light industry, will be represented by new J-125, a 10-inch circular saw. Alvin Stauber, sales manager, and Adolph Kliebhan, representative of woodworking division



Yates–American S-800 8-drum double-deck sander



39. Marcoloy, Inc., Springdale, Conn. Carbide tool and cutterhead equipment in all phases applying to woodworking industry, supplemented by exhibition of raw materials and processing of tungsten carbide from ore to the finished tool.



Selective angle range of new Marcoloy cutterhead

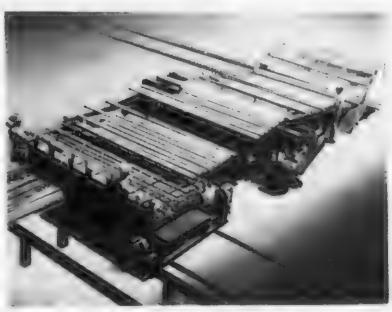
First showing with colored slides or film of a revolutionary new method in grinding milled-to-pattern knives in multiples on new Marcoloy universal tool and cutter grinding machine. Display of most recent development of new cutterhead having features permitting selection of cutting angles of knives for hard or soft wood through infinite selection within broad range of cutting angles. M. A. Corti, president; P. C. Richardson, vice-president and treasurer; Alex Onufer, engineering; David Kind, Midwest district manager; Lester Raymond, Northeastern district manager

40. Armstrong Machine Works, Three Rivers, Mich. Steam traps. T. H. Rea, sales manager

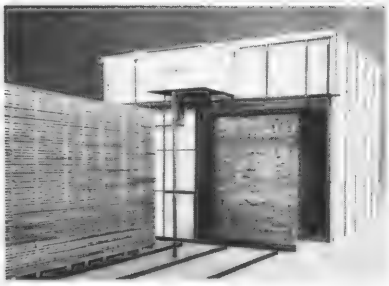
41 & 42. Moore Dry Kiln Co., Jacksonville, Fla., North Portland, Ore., Brampton, Ont., and Vancouver, B. C. Moore chain-arm stacker and Moore prefab kiln building. Wallace Adams and W. L. Heston, Moore Dry Kiln Co.; and G. Billington, managing director, Moore Dry Kiln Co. of Canada, Ltd.

43. McCulloch Motors Corp., Los Angeles, Calif. Chain saws. Sidney E. Campbell

44. Oliver Machinery Co., Grand



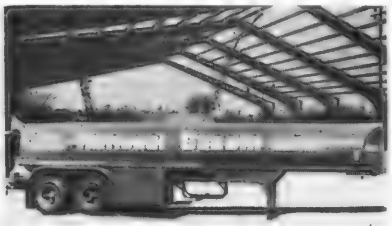
Moore chain-arm stacker



Moore prefabricated dry kiln

Rapids, Mich. Woodworking machinery. R. DeVries, sales manager, and R. T. White.

45. National Casein of New Jersey, Riverton, N. J. Applications of adhesives. Elmer Bergay and Richard Thomas, technical department; Obie



Applications of National Casein adhesives will be demonstrated

Derr and R. T. Cousins, salesmen, Riverton plant; George Tasker, technical department; A. H. Marten and Robert Archambeault, salesmen, Chicago plant

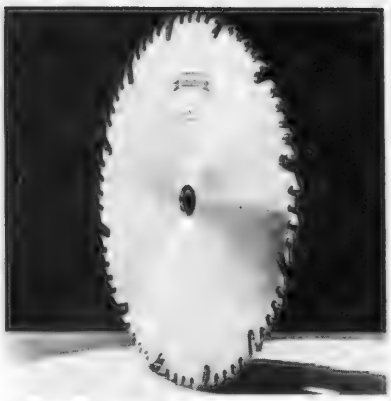
46. Ekstrom, Carlson & Co., Rockford, Ill. Woodworking machinery. Ray Rinehartsen and Ray Johnson.

Model MM rip saw made by Ekstrom, Carlson & Co.

47. Simonds Saw & Steel Co., Fitchburg, Mass. Representative display of complete line of saws, knives and files. Featured will be line of carbide-tipped saws, including rip, cut-off, combination, smooth trimmer, groover saws and dado heads, plus three new saws—No. 55 general purpose, No. 40 radial arm combination, and style KK smooth cutting cut-off saws. John Carney, George Cox, and James Doubleday

48. Cleworth Publishing Co., Cos Cob, Conn. Industrial Woodworking magazine. J. H. Goodenough, business manager.

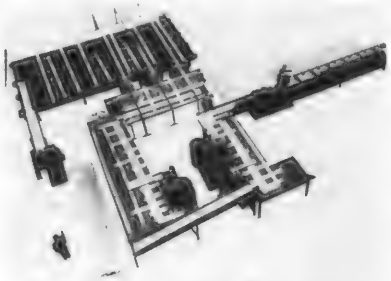
49. Price & Rutzebeck, Hayward,



Simonds No. 55 general purpose saw

Calif. Carbide-tipped tools. J. D. Rutzebeck, president

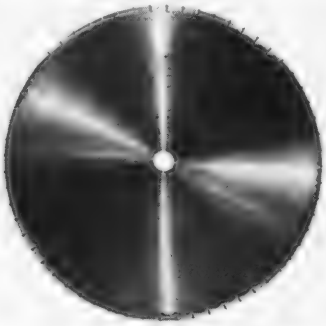
51. Tri-State Machinery Co., Dallas, Texas. Scale layout of finger jointing operation. Complete unit continuously and automatically scarfs stock up to 2 inches thick, lengths



Scale layout of Tri-State finger jointing operation

from 6 inches up, widths to 6, 8 or 12 inches. Completely assembles short stock and cuts glued up material to any given length up to 24 inches. H. T. Smith, president, and M. Cromeens, vice-president

52. Lemmon & Snoap, Grand Rapids, Mich. New carbide-tipped saw blade, known as "flying cutter" since it has no gullets between teeth. Car-



Lemmon & Snoap's carbide-tipped "flying cutter" saw blade

bide teeth are simply inserted and welded into saw blade at scientifically determined intervals. K. R. Lemmon and R. L. Painter

53. Soderhamn Machine Manufacturing Co., Talladega, Ala. Chipping and debarking equipment. Gus Jacobson, president

54. Wilco Machine Works, Memphis, Tenn. Hot presses and woodworking equipment. R. O. Wilson and Dan Copp

75. Mater Engineering, Corvallis, Ore. Engineering drawings, photos, articles describing mill modernization and automating operations. Milton H. Mater, president

77. University of Michigan, Ann Arbor. S. B. Preston

78. Pennsylvania State University, University Park. Newell A. Nort

79. Fjellman American, Inc., Joli Ill. Working model of new part board process. Olle Mellin, v president

80. State University of New Y College of Forestry, Syracuse. J. Meyering

81. Columbia Engineering Corvallis, Ore. and Vancouver, B Consulting industrial engineers MacDonald, vice-president

82. Michigan State Univer East Lansing. A. E. Wylie

83. North Carolina State Coll Raleigh. J. S. Bethel

84. U. S. Forest Products Lab tory, Madison, Wis. Use of l grade hardwoods. D. G. Colem

85. Pacific Mutual Door Mountainside, N. J. Lloyd Manl

86. Hugh C. MacLean Publicat Ltd., Don Mills, Ontario. Canad n Woodworker magazine, J. C e Reade, editor

87. Alabama Polytechnic Instit Auburn. D. B. Richards

88. Yale University, New Haven, Conn. G. A. Garratt

Sixteen Firms Giving Door Prizes to Be Awarded at National Meeting

Door prizes ranging from toys to furniture will be awarded at various events during the Eleventh National Meeting in Buffalo June 23–28, according to David W. Swanson, chairman of the prize committee. Sixteen firms have promised to give various items for this purpose.

The following list shows the prizes and sponsoring firms: one table, N quist Products; two pull-up tal Union-National Furniture Co.; ne Williamsburg table, Kittinger Co.; ne Barcalounger, Barcalo Manufactur Co.; two chairs, Sikes Co.; one et Melmac dinnerware, American Cy mid Co.; one belt axe, Trueter r Corp.; two chairs, Francher Furn e Co.; one smoker table, Heckman niture Co.; one Windsor arm Pennsylvania House; five carving Carborundum Co.; two chairs, Ja town Lounge Co.; 1000 plastic bo s of glue, Peter Cooper Corps.; l e quantity of abrasive cleaning Carborundum Co.; quantity of wo n spoons, Ovalwood Dish Co.; quan y of toys, Fisher-Price Toys, Inc.

Cover Photo

Meet Frank Kaufert, Next President of FPRS

An "outdoorsman" interested in hunting and fishing, a person whose favorite pastime is joining with friends and singing old German songs, a person to whom "life is just a bowl of cherries," and "Black Coffee Maker No. 1" have been used to describe the man who will become the next President of FPRS. Frank H. Kaufert, director of the University of Minnesota School of Forestry, is a person who enjoys people and looks for the humor in every situation.

One seemingly unhumorless incident which Dr. Kaufert likes to relate occurred in 1930 when he was attending the University of Halle, Germany, on a fellowship. Eager for sight-seeing but like most students, a bit short of funds, Kaufert travelled in a third-class car on a trip through Switzerland into Italy. Kaufert likes to describe his travelling companions on the trip. He was first joined by an Italian man who proceeded to lunch on a large loaf of garlic-laden bread. Then a woman boarded, bringing a goat with her into the car.

Kaufert's reputation as a coffee maker came about while he was associated with the Wood Preservation section at the U. S. Forest Products Laboratory from 1942–1945. Because he enjoyed swimming, hiking, and the outdoors, Kaufert organized many picnics at the lakes near Madison. Since gas rationing was in effect, the group either hiked out to picnic grounds in the Madison area or chartered a bus for longer trips. His ability to take coffee grounds and pine needles and brew them into a tasty cup of coffee caused him to be dubbed, "Black Coffee Maker No. 1."

A man who enjoys participant as well as spectator sports, Kaufert was also active in the men's bowling league while at the Forest Products Lab. He developed a rivalry with George Garratt (now dean of the Yale School of Forestry) and was willing to back his prowess at the game with a cash wager with Marie Roberts, now secretary to Dr. J. A. Hall, director of the Lab. At the season's end Mrs. Roberts was one up on Dr. Kaufert, so he paid off the wager by imbedding the dime in a piece of wood and covering it with glue.

To Kaufert one might apply the adage, "Work hard, play hard," for it seems to be the motto of his life. He has always worked extra hours, simply because he likes to work. He is considered to be a stickler for perfection, and always attempts to learn as much as possible about every facet of every job. Unlike some "eager beavers," Kaufert's ambition has inspired rather than antagonized his co-workers. He has always been willing to make sacrifices to achieve his aims, and worked as a prize fighter by participating in "club" fights on Saturday nights while an undergraduate in college.

The same industry which he applies to his work is also expended in the numerous organizations to which he belongs. A charter member of FPRS, Kaufert has served on the Publications Committee and on the National Executive Board. He was Vice-President in 1955–56 and President-Elect in 1956–57. He is also a member of numerous other organizations, including Alpha Zeta, Gamma Alpha, Gamma Sigma Delta, Sigma Xi, American Wood Preservers Association, Botanical Society, Hoo Hoo Club, and the Society of American Foresters. He has written numerous papers and is author or co-author of more than 50 technical papers and bulletins and 12 U. S. and foreign patents.

Minnesota Native

A native of Princeton, Minnesota, Dr. Kaufert received all of his degrees from the University of Minnesota, being awarded the B.S. in 1928, M.S. in 1930, and Ph.D. in 1935. Following receipt of his Ph.D., Kaufert joined the DuPont Chemical Company, where he remained until 1940. He then returned to Minnesota and accepted a teaching position, as teaching had always been his first love, and even though financial gain was greater in industry.

His teaching career was interrupted during the war when Kaufert helped train aircraft and packaging inspectors and worked on other projects at the U. S. Forest Products Lab. At the end of the war he returned to Minnesota, where he was named director of the School of Forestry in 1947. Although he has had opportunities to head schools of forestry in other states, Kaufert has chosen to remain in Minnesota because of the beauty of the country and the opportunities it affords the outdoorsman.

Kaufert met his wife, Ione, while both were students at the University of Minnesota. They were married in 1938 and have one son, Joseph.

Last October Dr. Kaufert returned from a 90-day visit to Korea where he helped re-establish the department of forestry at the University of Seoul. Upon his return he reported on conditions there and in the immediate area, commenting that the Presbyterian Mission where he stayed was one of the few adequate buildings.

For his "outstanding and distinguished" contributions to the forestry profession, Kaufert was selected as a Fellow of the Society of American Foresters, one of 75 foresters from the U. S. and Canada to have been selected for the honor in the 55-year history of the organization. This was quite an honor for the man who is also "Black Coffee Maker No. 1."

22 Plants Schedule Open House for Meeting Registrants

Twenty-two wood industry plants and laboratories within a 200-mile radius of Buffalo are scheduling open house on Friday, June 28, for the benefit of National Meeting registrants. Information regarding these plants will be available at the Touring Service desk on mezzanine floor of the Hotel Statler throughout the meeting.

1. **Cleveland, Ohio**—Klausner Cooperage Co., cooperage; and Taylor Chair Co., furniture
2. **Jamestown, N. Y.**—Crawford Furniture Corp., furniture; Maddox Table Co., furniture; Monitor Furniture Co., furniture; Union–National, Inc., furniture
3. **Falconer, N. Y.**—Knight Veneer & Panel Co., veneer
4. **Salamanca, N. Y.**—Fancher Furniture Co., furniture; and Jamestown Table Co., furniture
5. **Olean, N. Y.**—Daystrom Furniture Co., furniture
6. **Kane, Pa.**—Holgate Brothers, specialties and toys
7. **Horseheads, N. Y.**—National Homes Corp., prefabricated houses
8. **McDonough, N. Y.**—Ivon R. Ford, Inc., prefabricated houses
9. **Rochester, N. Y.**—Regent Specialties, Angle Genesee Corp., exhibit materials, precision wood parts; Eastman Kodak Co., cameras and film
10. **North Tonawanda, N. Y.**—Bennett Lumber Corp., pre-cut houses; Richardson Boat Co., cruisers
11. **Buffalo, N. Y.**—Mixer Lumber Co., wood preservation; McDougal-Butler Co., paint and varnish; Pierce & Stevens, Inc., coatings and adhesives
12. **Syracuse, N. Y.**—State University of New York College of Forestry, new $3.75 million wood products laboratory
13. **Kitchener, Ontario**—Perkins Glue Co., adhesives

INDUSTRY SUPPLIERS SPONSOR PAUL BUNYAN SMORGASBORD

Registrants and Families Will Be Guests for Smorgasbord, Falls Tour

More than 40 companies supplying materials and services to the wood industry will be hosts to meeting registrants and their families at the Paul Bunyan Smorgasbord and Tour of Niagara Falls, entertainment highlight of the Eleventh National Meeting June 23–28 in Buffalo.

The smorgasbord supper will be held at famous Brock Monument Park in Ontario, on the shores of the Niagara River, on Wednesday, June 26. In the evening, the group will visit fabulous Niagara Falls, one of the seven natural wonders of the world. The Falls take on added beauty at night when 1,440,000 candlepower of light are reflected to pentrate the banks of heavy mist. Vari-colored screens in front of the searchlights cause the Falls to take on the appearance of a rainbow.

The list of sponsors of this traditional FPRS event, as of May 1, included:

American Cyanamid Co., New York
American Manufacturing Co., Tacoma, Wash.
Bahnson Co., Winston–Salem, N. C.
Barrett Division, Allied Chemical & Dye Corp., New York
Bauer Bros. Co., Springfield, Ohio
Black Brothers Co., Inc., Mendota, Ill.
Borden Co., New York
Carborundum Co., Niagara Falls, N. Y.
Catalin Corp. of America, New York
Clark Equipment Co., Battle Creek, Mich.

More than 700 persons enjoyed Paul Bunyan Barbecue at 1956 National Meeting in Asheville, N. C.

Cleworth Publishing Co., Industrial Woodworking, Cos Cob, Conn.
Coe Manufacturing Co., Painesville, Ohio
Peter Cooper Corps., Gowanda, N. Y.
Delta Power Tool Division, Rockwell Mfg. Co., Pittsburgh, Pa.
Durez Plastics Division, Hooker Electrochemical Co., North Tonawanda, N. Y.
General Electric Co., Metallurgical Products Dept., Detroit, Mich.
Hitchcock Publishing Co., Wood Working Digest, Wheaton, Ill.
Kennametal, Inc., Latrobe, Pa.
Koppers Co., Pittsburgh, Pa.
Lilly Co., High Point, N. C.
Masonite Corp., Chicago, Ill.
Mattison-Greenlee Service Corp., Rockford, Ill.
Merritt-Solem Division, Solem Machine Co., Lockport, N. Y.
Moore Dry Kiln Co., Jacksonville, Fla., North Portland, Ore., Brampton, Ont., and Vancouver, B.C.
National Casein Co., Riverton, N. J.
National Starch Products, Inc., New York
Nelsonite Chemical Products, Inc., Grand Rapids, Mich.
Nicholson Manufacturing Co., Auburn, Wash.
Pacific Lumber Co., Scotia, Calif.
Pannill Veneer Co., Ltd., Kitchener, Ont.
Perkins Glue Co., Lansdale, Pa.
Preston Woodworking Machinery Co., Ltd., Preston, Ont.
Protection Products Manufacturing Co., Kalamazoo, Mich.
Reichhold Chemicals, Inc., White Plains, N. Y.
Simonds Saw and Steel Co., Fitchburg, Mass.
Soderhamn Machine Manufacturing Co., Talladega, Ala.
Southern Screw Co., Statesville, N. C.
Standard Dry Kiln Co., Indianapolis, Ind.
Synvar Corp., Wilmington, Del.
Timber Engineering Co., Washington, D. C.
U. S. Plywood Corp., New York
Washington Iron Works, Seattle, Wash.
Wilco Machine Works, Inc., Memphis, Tenn.
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.
S. A. Woods Machine Co., Boston, Mass.
Yates-American Machine Co., Beloit, Wis.

Industry suppliers sponsoring 1956 Paul Bunyan Barbecue were listed on banner.

Two Sessions Scheduled on Chemical Utilization Advances

Two stimulating technical sessions on the chemical utilization of wood will be held during the National Meeting in Buffalo, according to Dr. A. S. Gregory, division program chairman. The sessions have been divided to group the papers of special interest to technical personnel interested in lignin utilization and those of primary general interest to the forest utilization industries.

Session VIII on Lignin Utilization will complement two outstanding sessions given during the past year in other societies on the chemical structure of lignin and its biochemistry. Several industrial corporations which are taking a lead in the lignin utilization field and institutions doing research in this field are presenting papers which will substantially increase the knowledge available on this important subject.

It is anticipated that other companies and individuals, who are not able to present papers at this session but who have valuable experience along these lines, will be drawn into a general discussion led by a nationally known man in the field of lignin chemistry.

The aim of Session XI, General Chemical Utilization, is to acquaint

members of FPRS and other interested persons with the opportunity of increasing return from the forest crop by chemical utilization. New information on the composition of some of the available raw materials will be discussed, along with advances in established methods and additional knowledge relative to selected chemicals that can be produced.

14 Division Meetings Open to All Registrants

All registrants at the Eleventh National Meeting in Buffalo are invited to attend meetings of the 14 FPRS Subject Matter Divisions on Monday, June 24. Seven meetings will be held concurrently from 8:30 to 10:30 a.m., with seven others scheduled from 10:30 a.m. to 12:30 p.m.

The first group will include the following divisions: Logging, Chemical Utilization, Machining, Quality Control, Glues and Gluing, Drying, and Packaging. Meeting in the second group will be the Lumber Manufacture, Wood Preservation, Finishing, Veneer and Plywood, Composition Board, Marketing, and Industry-Education divisions.

The divisions will discuss plans of their group for the coming year, as well as current problems facing their segment of the industry. The wide variety of subject matter covered will give each registrant an opportunity to attend one or more meetings in his own and related fields.

Committee Agendas

Logging

Chairman: F. C. Simmons

1. Report of activities during the past year by the Chairman
2. Discussion of proposed activities during the coming year
   - A. Report on developments
   - B. National Meeting program
   - C. Section meetings and Section activities
   - D. Cooperation with other organizations
   - E. Possible project work: compilation of state safety legislation, literature reviews, other
3. Discussion of steering committee membership
4. Other business

Quality Control

Chairman: Charles Latimer

1. Developments in quality control in forest products since 1956 National Meeting
2. Methods of obtaining information on application of quality control methods in various segments of the woodworking industry
3. Organization of the Division

Glues and Gluing

Chairman: Alan A. Marra

1. Progress reports of committee chairmen covering:
   - A. Recent developments in each field
   - B. Recommended subject matter additions
   - C. Recommended personnel additions
   - D. Possible sources of future technical papers
2. Program for 1958 National Meeting
3. Other business

Lumber Manufacture

Chairman: Milton H. Mater

1. Old business
   - A. Field research questionnaire (N. C. Bye, subcommittee head)
   - B. Mechanical improvement questionnaire (E. P. Ivory, subcommittee head)
   - C. Sawmill nomenclature (M. H. Mater, subcommittee head)
   - D. Other old business
2. Discussion of papers
3. New business
   - A. Discussion of general division organization
   - B. Discussion of advisability of forming Region 15 covering Arkansas, Louisiana, Texas, and Oklahoma
   - C. Other new business
4. Election of officers

Wood Finishing

Chairman: F. H. Thomas

1. Cataloguing information on research work being conducted in the furniture finishing field
2. Current developments in the wood finishing field
3. Division membership
4. Suggestions of papers for 1958 National Meeting

Veneer and Plywood

Chairman: H. O. Fleischer

1. Reading of minutes of previous meeting
2. Annual industry report of Veneer and Plywood Division
3. Survey of research facilities available to the veneer and plywood industry. Report of progress to date by Dr. William T. Nearn and Fred E. Dickinson
4. Steering committee membership and organization for 1957–1958.
5. Plans for general technical session at the 1958 National Meeting
6. Other business

Marketing

Chairman: R. D. Pauley

1. How far does committee desire to go along the lines of market research? Should activities be confined to marketing problems other than those covered by trade associations?
2. Does division desire to have other meetings in addition to one at National Meeting?
3. Should the work of the Marketing Division subject matter discussions be carried into Section meetings?
4. How far should the division as a group go in the promotion of forest products?
5. Does the division need a monthly, bimonthly, or yearly newsletter or summary on the marketing of forest products?
6. Should the division plan on having a technical session at the 1958 National Meeting?

Industry–Education

Chairman: A. J. Panshin

1. Discussion of Everett Ellis' report of the results of survey of recent graduates in wood technology
2. Discussion of present status of career bulletin
3. Planning a technical session for the 1958 National Meeting
4. New business

FPRS Salutes . . .

Men Contributing Time and Efforts for Furtherance of the Society and Wood Industry

J. E. BATSON

Jack E. Batson—Coordinating the efforts of local committee chairmen, Jack is vice-chairman in charge of local arrangements for the National Meeting in Buffalo. As the Society has grown, so has the size of the National Meeting and the local arrangements chairman's job. Part of Jack's responsibility will be shared by his wife, who is in charge of the Ladies Program. A native of Edmonton, Alberta, Jack graduated from the University of Alberta with a B. S. degree in civil engineering. He joined the Kittinger Co., Buffalo furniture manufacturer, in 1932 and is now production manager of the firm.

F. F. WANGAARD

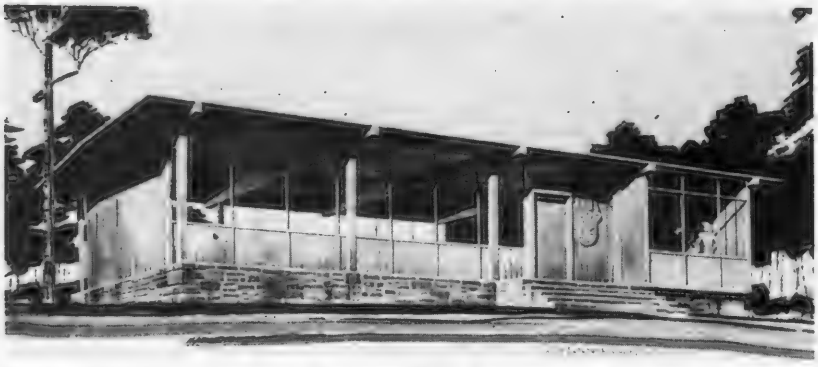
Frederick F. Wangaard—Long a familiar face at FPRS National Meetings, an extended trip abroad will prevent Fred from attending the 1957 and 1958 meetings. Fred recently resigned as Publications Committee Chairman because of his forthcoming trip. He will spend six months as a consultant at the Forest Products Laboratory in the Philippines, then go to Oslo, Norway for six months as a Fulbright scholar. Fred received B. S. from the University of Minnesota, M. S. and Ph. D. degrees from the New York State College of Forestry. Fred was on the University of Washington faculty and the staff of the U. S. Forest Products Lab before joining the Yale School of Forestry following World War II.

Six Students Awarded NLMA 1957 Scholarships

Six outstanding forestry school students have been awarded special 1957 scholarships by the National Lumber Manufacturers Assoc. Each winner will receive a cash award of $500, travel expenses, and ten weeks' on-the-job training at the Timber Engineering Co. laboratory, Washington, D. C.

The winners, chosen on the basis of scholastic records, aptitudes, interests, and extra-curricular activities from students nominated by 13 of the nation's leading forestry schools, are: W. H. Hunt, Colorado A & M College; R. F. Sutton, Yale University; J. S. Fujii, University of Washington; M. H. Bengelsdorf, University of Michigan; C. G. DeRidder, Michigan State University; and D. A. Strause, Oregon State College.

Fund-Raising Drive Has Good Start



Architect's drawing of proposed FPRS Executive Office Building.

R. H. BERRY

The drive to raise $60,000 toward a permanent, home executive office building in Madison, Wis. is off to a good start, according to Chairman R. H. Berry, Burney, Calif.

The second phase of the program has been to approach companies and foundations which make up or contribute to the vast forest products industry. Early response from this effort indicates a total of more than $2,650 subscribed in the first weeks of the campaign.

Ralph L. Smith Lumber Co., Anderson, Calif., recently gave Mr. Berry a check for $1,000 through General Manager A. Bristow Hood, who is also president of the Western Pine Association. E. P. Ivory, president, Ivory Pine Co., Dinuba, Calif., donated $500, and Chairman Berry, vice-president and general manager of Scott Lumber Co., Burney, Calif., has signed up for $1,000. In addition, the Ohio Valley Section contributed $100 and the Arthur D. Little Co., Cambridge, Mass., gave $50. A number of other companies and foundations are favorably considering contributions.

Ohio Valley Section Chairman John Wilson hands $100 check for building fund to North Central Regional Board Member R. L. Hiller (right). Looking on are Secretary-Treasurer John Young and Vice-Chairman Paul Fenn.

The third phase of the fund-raising drive, to be launched about the time you receive this issue of the JOURNAL, is the mailing to the entire membership of a color brochure entitled, "Research is the Great Light of Commerce," describing our need and soliciting individual contributions. It is hoped that members will respond generously in such amounts as they deem desirable.

The Executive Board believes it advisable to proceed with a permanent building at this time for these reasons:

1. We are in a growth situation, with membership expected to reach 7,500 to 10,000 in the next decade.
2. A building of our own will represent a substantial reserve on which to draw in time of need, a permanent investment in the form of real property.
3. Our present rental of $3,000 per year would adequately cover maintenance and upkeep costs for a larger building.
4. While present space is adequate, we can efficiently use additional space.
5. This building, representing the newest in forest products technology, would be an "advertisement" for wood, and a source of widespread interest.

EMPLOYMENT SERVICE

Positions Offered

No. E-271—Midwest millwork firm has opening for project engineer to be responsible for design and development of products. Needs man with B.A. in architecture or architectural engineering, interested in product design. Salary based on experience and ability; profit-sharing plan. (June)

No. E-273—West Coast organization has opening in engineering-research lab for graduate wood technologist or wood engineer with broad background in the basic sciences and intensive training in advanced wood technology. A good knowledge of statistical methods and familiarity with plywood manufacturing desirable. Must be able to handle shop and laboratory equipment and techniques. Salary dependent on qualifications. (May)

No. E-274—Time standards man or industrial engineer sought by Midwest firm to assume responsibility in the field of methods study, motion and time studies and rate setting. (June)

No. E-275—Building products manufacturer in Midwest seeks mechanical engineer for design and development of mineral production equipment, jigs, and fixtures for use in manufacturing operations. Must hold engineering degree from school of recognized standing. Should have knowledge of machine shop practices and fabrication methods as well as an interest in machine design. Salary based on applicant's experience and capacity for design and production engineering. (June)

No. E-278—Established lumber producer in Idaho has opening on products development staff. Needs man with experience or extensive knowledge in gluing techniques and/or structural engineering. Possibilities for administrative position in future utilization plants. Salary based on experience and ability. In reply, give age, experience and when available. (June)

Employment Wanted

No. 412—June 1957 graduate of Iowa State College, B.S. in wood utilization, seeks responsible position in furniture manufacturing. Six years' experience in furniture upholstery and cabinet work. Single, age 32. (May)

No. 414—Iowa State College graduate, B.S. in forestry (wood technology option) seeks wood technology or production position in Midwest or eastern U. S. Will consider sales work. Eight months experience in sales for lumber importers. Age 22, available for employment in June. (June)

No. 416—Indiana University graduate, age 41, seeks position as plant manager, assistant plant manager, chief industrial engineer or production manager in plant having production, cost, or supervisional problems. Past experience in positions of plant industrial engineer and chief industrial engineer provided familiarity with methods, layout, machinery, material yield, quality, personnel, standard cost, incentives and the solving of supervisional problems. Will locate anywhere. (June)

No. 417—Student, 21, seeks summer job in eastern U. S. in plywood or building board industry. Interested in research. Available for employment June 5. Earl K. Blixt, 67 Cedar St., Morrisville, N. Y. (June)

No. 418—Alabama Polytechnic Institute graduate, B.S. in wood utilization seeks position in wood products field. Main interest in sawmilling, wood preservation, timber procurement, gluing, and wood seasoning. Presently completing a two year tour of duty in Army. Age 24, married, prefers Gulf states, Southeastern U. S., or Colorado. (June)

No. 419—Graduate forestry engineer, age 34, married, seeks management position with opportunities for advancement. Experience in forest management, logging road construction, sawmill, box factory, particle board plant, lumber and particle board sale. (June)

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When you are looking for waterproof, strong, durable bonding, consider the names on this page. Each represents a resorcinol-base adhesive which will give you:

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- . . bonds that resist acids, greases and most solvents.
- . . bonds that withstand the shrinking and swelling of wood.
- . . bonds that set at room temperature.

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The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
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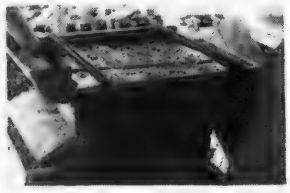

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FPRS Forest Products Journal

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May, 1957

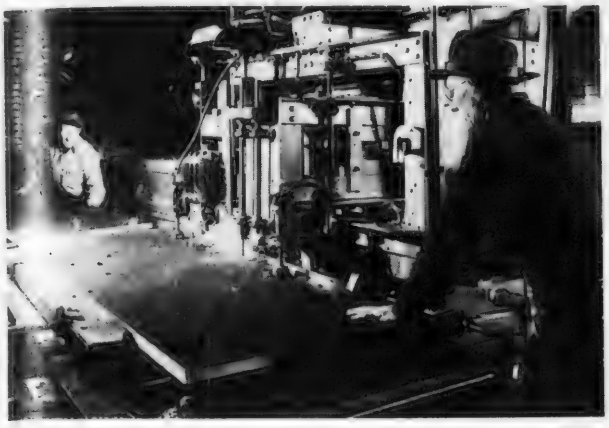

Fig. 1.—Machining of interior doors with hardboard skins.

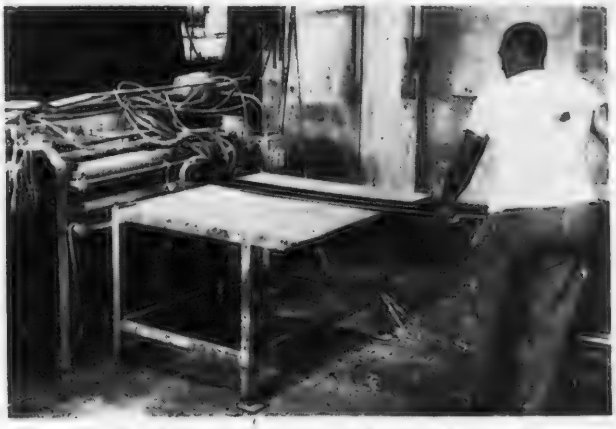

Fig. 2.—Roller coating of overlaid plywood trim strip.

Use of Composition Board and Other Wood-Base Products in Mass Building[1]

WILLARD J. WORTH

Head, Research and Development, National Homes Corp., Lafayette, Ind.

General physical properties desirable, specific properties important to prefabrication, and the use of wood products as finish material are covered. Structural applications of wood-base products are discussed. The influence of building codes is pointed out and the outlook given for future uses of wood in mass building.

Introduction

THE PURPOSE of this paper is to discuss those factors in mass homebuilding that influence the use of wood products, particularly composition board and other wood sheet materials. Basically, it concerns prefabricated housing. It should be pointed out, however, that many of the properties and characteristics that would be important or desirable to the manufacturer of prefabricated homes, would be equally important to any progressive builder.

It might be well at this point to explain that the term "prefabricated" may cover a wide degree of fabrication, ranging from the precutting of framing up and through the panelization of framing, insulation, and skin materials into a complete panel ready for site erection and finishing. The lower limit of fabrication is controlled by the economic advantage to the builder (who may be able to economically duplicate the fabrication himself), while the upper limit is dictated by the economics of presently available transportation. National Homes' methods fall into this latter classification and emphasis will be placed on this segment of the industry.

[1] Presented at Session XI, Wood Composition Board, FPRS Tenth National Meeting, June 4–7, 19[illegible] in Asheville, N. C.

Author: W. J. Worth received B. S. degree and did advanced work in architectural engineering at U. of Illinois. A registered architect he was employed for two years as research associate at the U. of Illinois Small Homes Council. His work has included research on the structural, economic, and code requirements of wood framing for dwellings. Worth is the designated representative to FPRS of National Homes Corp., company supporting member.

Potential Volume in Sheet Materials

Based on an estimated volume of 1 million non-farm, single family houses (which is problematical for this year but conservative for the coming ten years), an annual potential volume of approximately 6 billion square feet of sheet material exists in the housing market. This may be broken down approximately as follows:

	Million Square Feet
Sheathing materials	1,750
Interior finish materials	2,750
Exterior finish materials	1,100
Miscellaneous	400
Total	6,000

This volume, which is currently being shared by wood, wood base, mineral base, and plastic products, must certainly be a tremendous incentive for the producer of composition and wood base products. For exactly the same reason, the manufacturer of prefabricated homes looks to these materials as an area for significant cost savings. Here, with a volume of 6,000 square feet per house, an improvement of one cent per square foot is reflected by a $60 savings per house.

With the exception of sheathing, these materials also enjoy the advantage of being of prime importance to the ultimate home-owner in judging the merits of competitive houses – since they are finish materials. For this reason, a superior product at equal cost is equally important to the builder.

Basis for Use of New Materials

Basically, then, from the point of view of the builder, the use of a new material must be justifiable on the basis of equal performance at lesser cost, better performance at equal cost, or as a sales promotion tool. In computing the advantages or disadvantages of a proposed material, its relation to other portions of the house must be considered and the influence of this relationship on total cost estimated.

Next to be discussed will be the potential application, along with a de-

Fig. 3.—Composition board interior finish material. Note the room-size panels and lack of joints. (This material is offered as an alternate on some houses and is not standard throughout.)

scription of present uses, of wood composition board and other wood base sheet products in prefabricated houses.

Structural Applications —Wall Sheathing

To many people the term "prefabricated house" is synonymous with the term "plywood house." This has a historical basis, for the earliest successful attempts at prefabrication in this country leaned heavily upon the use of plywood and today it is still a dominant material in many systems of prefabrication.

Since the prefabricator is vitally concerned with the economical transportation of his product to dealers on an ever expanding scale, bulk and weight of materials and of assemblies are extremely important to him. For this reason, many prefabricators have adopted the basic method of stressed skin construction, or a variation of it, as a means of reducing weight and shipping space, while maintaining the necessary strength and rigidity to meet the standards under which the vast majority of houses are built. Through the use of plywood bonded to the framing on one or both sides, the size of the basic framing members may be reduced, weight and space saved at no sacrifice of strength or regidity. For example, National Homes' present method of exterior wall construction utilizes nominal 2- x 3-inch studs on 16-inch centers with plywood glued and nailed to the exterior side, gypsum board glued and nailed to the interior side.

The substitution of the conventionally used fibreboard or composition board sheathings or of the newer wood base boards for plywood must therefore entail the use of heavier framing with the extreme penalties of cost, weight, and bulk; or as an alternate, these products must possess the physical characteristics necessary for their use as structural materials in aiding the panels to resist compression, bending, racking, and impact.

This is an area where there has not been sufficient investigation to adequately define the minimum properties of the board necessary for these functions. The basic standards for the completed assembly exist in performance standards and in building codes, but to date plywood remains the only standard for structural skin material. Conceivably, an improved balance between tensile and shear strength, while maintaining a modulus of elasticity and thickness appropriate to the span between framing, might result in the economical application of fiber, composition, or chip boards as structural skin materials.

Almost certainly a major problem in the design and development of such a board would be the necessity for establishing a glue bond between the board and the framing. Our experience with wood base products leads us to believe that the glue line itself would not be critical but rather that the internal shear between plies, fibers, or chips would have to be designed for the specific conditions of loading and use. Since an intimate bond between skin material and framing will result in expansion and contraction of the skin, exhibiting itself as warpage in the completed panel, it is necessary that dimensional stability under moisture changes be of the same order as that of plywood.

In addition to its stressed skin action, the wall sheathing must transfer loads, such as wind, to the framing and must, in addition, provide support for the exterior finish material. Again a problem peculiar to mass building is encountered. Due to the nature of mass building, the prefabricator must provide variety of appearance while maintaining the advantages of a mass produced product. One of the principal means of providing this variety is through the use of varied exterior finish materials. Included among the five or more usual finish materials are cedar shakes and asbestos-cement shingles, both of which, for efficient operation, must be capable of being applied directly to the sheathing.

At the present time there is no application device, nail, staple, etc. that is nationally approved by the Federal insuring agencies for the application of these or similar products to the fiber or composition board sheathings presently in use. This is a real disadvantage to the mass builder and one that severely limits the usefulness of these products. This is especially true since shakes and shingles are two of the lowest cost coverage materials he can offer.

One thing that must not be overlooked in this discussion of wall sheathing is the possibility of a single material serving simultaneously as the sheathing and exterior finish material. Although this method (so called single construction) is prohibited by many building codes, the trend today is toward the more liberal performance type of code—plywood has been and is being successfully used as such a material. The inclusion of the function of exterior finish obviously justifies a considerable increase in allowable cost, and the possibility exists that a laminate of two materials might better serve the structural functions outlined above.

Exterior Finish Materials

In addition to wood shakes, asbestos shingles, and masonry veneer as exterior coverage materials, prefabricated houses are currently offered with grooved plywood, plywood with resin-impregnated paper faces, or hardboard siding. These last two are considered to be excellent products, particularly from the durability and paint retention standpoint. It has been noted that, unlike natural wood products, local failures in the paint film do not lead to rapid deterioration of the surrounding film.

Exterior finishes present an extremely difficult problem since they involve appearance, taste, and personal preference. The manufacturer of a coverage material is advised to use his material without imitation of existing materials, yet the smooth, flat surfaces of many of the wood base materials result in a bleakness that stimulates sales resistance. Attempts to take advantage of pattern or grain in these products to achieve more texture and warmth are severely limited by the presently available finishes that are durable only when so heavily pigmented as to hide the pattern.

Basically the prefabricator prefers to deal in the largest size sheet that may be economically handled. This in turn creates an appearance problem at joints. The most successful attempts at solving this problem have been the grooves, striations, or battens that confuse the eye and thereby make the board or panel joint indistinguishable. It is expected that similar devices will continue to be utilized in the future and that the trend toward single construction and larger sheet sizes will continue.

Roof Sheathing

The same basic method of stressed skin construction with dependence upon the sheathing as a primary structural material as employed in exterior walls may be used in the roof panel construction. However, with the present trend toward truss construction, this factor is probably becoming less important.

Conventional spacing of roof framing is 16 inches o.c. (on center) with a trend toward 24-inch spacing. It can be demonstrated that framing costs per square foot go down as spacing is increased to 2-, 4-, 6-, and 8-foot. o.c. This is true of post and beam type of framing where the savings between 4- and 8-foot o.c. would be approximately $35 per house. It is more significant in the trussed roof method of construction where between the spacings of 2- and 8-foot o.c., savings of $80 per house could be realized. Proportionate savings in framing could be gained at intermediate spacings.

This immediately suggests that a potential market in the post and beam method of framing exists for sheathing materials capable of spanning beyond 24 inches where such materials can be produced at a premium over conventional materials that is less than the differential between framing cost. In addition, where the board remains exposed and has sufficient insulating value, more may be saved.

While this method of framing may be attractive to the precutter, it is basically a site fabricated system and for this reason the prefabricator may be more interested in the trussed roof system with horizontal ceiling. Here the situation is not so favorable for the insulative, acoustical, and decorative properties of the board are of no significance. In addition, the cost of a ceiling system must be deducted from the roof framing savings. This suggests that a board for these purposes should achieve its structural function through high density rather than through depth, and this in turn would improve the nail holding characteristics which are necessary for the application of roofing.

Fig. 4.—Exterior view of house with hardboard siding, overlaid plywood gables, and composition board soffit material.

For the ceiling system, the more normal composition or fiber board of low density and greater depth may be suitable, although it is likely that a subframing system and the more conventional materials may be more economical and more acceptable at the present time. This leads into the single largest classification of sheet materials, the interior finishes.

Interior Finish Materials

Interior finish materials amount to approximately 2,750 square feet per house. Here, as with exterior finishes, taste, preference, and final appearance cannot be overlooked. In the interior non-bearing partitions, the prefabricator may reduce framing sizes and rely upon the finish materials to provide stiffness, not strength, to the panel system. This in turn requires a glued or glued-nailed joint between framing and skin material.

The natural warmth and texture of natural wood is much admired as an interior finish material, but experience has proved that in the mass building market it is best suited to small decorative areas. The general preference in large areas is for a smooth, paintable surface free from joints. Basically, a resemblance to the traditional plaster finish is most popular and in some areas this extends to the textured and sanded finishes which even more closely resembles a plastered surface.

Gypsum board has gained its position in the interior finish field as an economical means of providing such a surface. This has only been possible through the development of a workable, though certainly not perfect, joint taping and nailing system.

The problem of joints and of connection to the framing is more critical in an interior finish than in an exterior material. The following appears to be the most valid approach to the problem of utilizing the potential advantages of manufactured wood base sheets:

The volume house today is a single story structure with a nominal ceiling height of 8 feet. The maximum length of wall without intersecting partitions (with occasional exceptions) is 16 feet. Therefore, a sheet material of 8-foot width and available in lengths of 16 feet or longer would be capable of presenting a jointless, unbroken surface.

Such a material was, in fact, a basic part of National Homes' method of wall construction up until approximately 1½ years ago. Panels were designed to join behind intersecting partitions. Sheets up to 20 feet in length and panels of equal size were successfully handled both in the factory and during site erection. The continuity of the large sheets added unusual rigidity to the panel during handling and during service in the completed house. A system of wood moldings was used to conceal intersections at corners, at the ceiling, and at those panel intersections that were exposed. Since the material, a composition board, was sensitive to moisture content changes, the molding system also functioned as a means of concealment for dimensional changes of the board.

Sales resistance to the appearance of the molding system eventually led to the abandonment of this system, in spite of the many excellent advantages it offered—structural strength, factory finished surface, and minimum joints.

On the basis of this experience, it would appear that a dimensionally stable, structural, fiber, or composition board available in 8-foot widths would, in combination with a workable jointing system for corner and ceiling intersections, result in an interior finishing system of sufficient advantage to the mass builder to justify a substantial increase in cost over presently available materials. Shipping weight would be lower; the amount of field

finishing would be reduced with a resultant cost saving and a lesser hazard of unsatisfactory workmanship; an opportunity would be opened up for factory priming of the material or possibly for a pre-finished panel; with sufficient shear strength in the board fibers or plies, the opportunity would exist for elimination of all nails and the reliance upon a glue bond to connect the board to the framing. This in turn would further reduce field finishing costs but most important it would free the builder from the single biggest problem with dry wall construction—nail pop.

During the period of use of the 8-foot wide sheets of composition board, we entered into a research project to find an adhesive for this function applicable to our assembly methods. Those adhesives tested, both in the laboratory and in service, were not suitable for the job. With the switch to gypsum board the project was abandoned, since a glued-only connection is not a recommended procedure for gypsum board—this reflecting the degree of shear resistance in the paper covering. We feel confident that sufficient progress has been made in the field of adhesives during the past year so that a glued-only connection to a suitable composition or fiber board would be worth further study.

One more property is necessary in conjunction with board used as an interior finish material on an exterior wall. This is resistance to vapor transmission—the function of a vapor barrier. Ideally this property should be provided as an integral part of the board and in such a position as not to interfere with the glue joint between board and framing.

Miscellaneous Applications

In addition to the principal uses outlined above, there are several other common uses of wood base sheet materials in mass building—door skins, underlayment for flooring, and soffit material, to name a few. Presently we are using an exterior grade of wood base composition board as soffit material and hardboard skins for the interior doors.

A trend has been noted toward materials of lesser durability in soffit applications, evidently based on the assumption that the sheltered location of such material justifies a reduction in durability. This trend has appeared in those geographical areas where the climate is most favorable. We do not have sufficient information to judge the performance of such materials in more rigorous climates, but we expect further developments along these lines.

Influence of Codes and Regulations

The vast majority of mass-built houses are offered to the ultimate home owner under mortgages insured by either the Federal Housing Administration or the Veterans' Administration. To the prefabricator, operating under many regional jurisdictions, national acceptance of proposed materials is of paramount importance. This in turn must be supplemented by regional valuations that are commensurate with the actual cost of the material to the builder.

New materials and unconventional uses for old materials must also be approved under the local codes at all levels. The wide variance between codes and the obsolescence of many codes is a potential hazard to all progress in the building industry. The solution to this problem is the wider adoption of the preformance type of code under which new methods may be approved or disapproved on the impartial basis of technical evidence. The use of the performance code, which logically began in the larger municipalities, is becoming more common in the smaller towns and currently many communities are in the process of modernizing their codes. This is an encouraging sign and one that should have the support of all those interested in the technology of building.

Summary

1. Large scale expansion of the market for wood base composition, fiber, ply, and chip boards in the housing market will be accelerated by closer cooperation between manufacturer and builder with more attention to specific end use.

2. Solution of the economic problems will be more feasible through the consideration of entire assemblies and the physical properties necessary—strength, rigidity, insulation, vapor transmission, durability, and appearance rather than through the consideration of a single product without reference to other materials involved. This will require the development of techniques for the economical testing and evaluation of the many combinations of framing spacing, and material that may be feasible.

3. Even within a specific usage, such as interior finishes, the potential will be improved through the development of materials as part of a system to include connection to framing and to other materials, jointing methods and finishing techniques.

4. Basic and authoritative technical data will aid materially in the builders' evaluation, in the obtaining of necessary approvals, and in the merchandising of new products.

5. In comparison to competitive materials with fixed properties, the ability of the manufactured wood base boards to be varied in density, resin content, fiber length, etc. with the resulting influence on their physical properties appears to be a prime advantage. This suggests that they are capable of gaining competitive advantage against less expensive materials through the design of structural or other functions into the product that will provide corollary savings to the builder.

6. In connection with such properties, the possibility of 8-feet wide sheets for both the exterior sheathing and for the interior finish material of wall construction seems a logical development, as does the extension of roof sheathing boards to greater spans

Boring Tests of Particle Board[1]

ROBERT J. HOYLE, JR.

Research Assistant in Forest Utilization, State University of New York College of Forestry, Syracuse, N. Y.

A study was made of the relationship of RPM and feed speed to the production of well machined holes for dowel joints in particle board. Results were compared of boring two flat-pressed and an extruded board, as well as yellow poplar core stock. The influences on dowel joint strength of particle board density, particle direction, and use of face veneer are discussed.

THE WIDESPREAD INTEREST in particle boards and the rapidly expanding facilities for their manufacture are quite naturally attended by a demand for factual information about their machining properties. The progressive attitude of particle board manufacturers in support of research programs on this new product portends new developments and continuous improvement. We expect particle boards to gain rapid acceptance throughout the wood-using industry.

A series of experiments to determine the influence of boring tool operating speeds and feed rates on the strength of glued dowel joints was recently completed. The results were reported in a paper presented at the Tenth National Meeting of FPRS in June 1956.[2] Although confined to wood, they revealed some basic information on the boring process of much general interest. This research has been expanded to obtain a better understanding of the boring process as applied to particle boards.

Review

The aforementioned experiments were limited to a single dowel size, 3/8-inch diameter. Machining speeds of 1620, 2880, and 4430 rpm, combined with feed rates to produce shaving or chip thicknesses of 1/128, 1/64, 1/32, and 1/16 inch, were used in these tests. The tool style was the commonly used double spur machine bit. Although tool diameter was limited to a single size, the implications which may be drawn and applied to other boring tool sizes will be helpful to tool engineers in the wood-using industry.

The tests using particle board material differed from those using solid wood only in the working materials. For this reason, and because a similarity in results were evident, a brief review of the earlier tests on solid wood is in order.

The surface quality of the wall of a bored hole is affected by the thickness of chips cut by the boring tool and by the speed of rotation of the tool. The chip thickness has less influence on physical roughness of the hole wall for species of high and uniform density than for species with low density material in the springwood and summerwood, or in springwood areas only. Ruptured fibers in the wall surfaces of low density species bored at high feed rates and large chip thicknesses materially weaken the wood-glue bond in dowel joints. Species of high and uniform density are less subject to tear-out of the hole wall fibers. Therefore the wood-glue bond in dowel joints is not materially weakened by the heavier cuts, for species of high density and uniform structure.

Boring rpm has a greater effect on joint strength than does chip thickness. The rotational speed of the tool influences joint strength through its heating effect on the wood. The rapid generation of heat at high tool rpm causes low wood-glue bond strength. The heating and often charring of the hole wall surface is believed to affect the wood-glue bond by changing the chemical nature of the surface and its ability to form strong molecular bonds. A similar reduction in joint strength at low boring rpm, particularly for dense species, is attributed to longer exposure of the wall surface to the heated tool even though the tool temperature may be somewhat lower at low rpm than it would be at higher speed. The harmful effect upon glueability is evidently a temperature-time relationship.

On the basis of these tests, 2880 rpm was the optimum boring speed and 1/64 to 1/32 inch was the optimum chip thickness range. Particular importance is attached to the fact that extremely low feed rates resulting in the cutting of thin shavings cause overheating of wood surfaces which fail to develop strong wood-glue bonds.

To adapt this information to tools of other diameters, the available experimental evidence and operating experience indicate that tool speed should be changed in inverse ratio to tool size, whereas chip thicknesses should conform to the range mentioned above.

Particle Boards

The particle boards were contributed by three different manufacturers and represent the flat-pressed and extruded types (Fig. 1). The extruded type used in this work was made in a horizontal extrusion press. Another type of extruded board machine is the vertically arranged press. No material from this type of machine was included in these tests.

Table 1 contains descriptive information on the various board materials. The particles used in these boards were produced in hammer type hogs rather than knife hogs or flake machines. The materials were true particle boards rather than flake boards.

The particles in the flat-pressed boards displayed a strong tendency to align themselves with their major surfaces in planes parallel to the panel face or platens. In the extruded board, particle alignment was perpendicular to the panel surface, but particle direction was more varied than in the flat-pressed material.

All of the particle boards were made with resin binders. The type of resin and proportion used in formulation of the board mixture has not been determined.

Joint strength is dependent upon direction of the bored hole with respect to the plane of particle alignment in much the same way that joint strength in wood bored across the grain differs from that for joints bored parallel to the grain.

[1] Presented at meeting of FPRS Northeast Section, Oct. 25–26, 1956, in New York City.

[2] Hoyle, R. J., Jr. 1956. The effect of boring speed and feed rate on the strength of glued dowel joints in tension. For. Prod. Jour. VI (10):387–393.

Author: R. J. Hoyle, Jr. holds B. of M. degree from Cornell University, M. S. in wood utilization from State University of New York College of Forestry. Formerly employed by Taylor Construction Co., Eastman Kodak Co. and Timber Engineering Co., he is now in charge of wood machining research at the parent forestry college.

Table 1.—DESCRIPTION OF PARTICLE BOARDS INCLUDED IN THE RESEARCH

DESIGNATION	A	B	C
Process of Manufacture	Flat-pressed	Extruded-horizontal	Flat-pressed
Surface and Structure	Softwoods, mainly ponderosa pine	Hard and softwood species. Eastern red cedar, yellow poplar, soft maple, mahogany, willow, ash, red oak, magnolia, basswood and walnut.	Softwood species. Eastern white pine, hemlock, Spruce, and bark
Particle description	Hogged material produced from lumber waste. Particles aligned in planes parallel to panel surface. Particle length—$\frac{1}{8}$" to $\frac{1}{4}$" Particle width—$\frac{1}{16}$" to $\frac{1}{8}$" Particle thickness—$\frac{1}{32}$"	Hogged material produced from lumber and veneer. Particles more heterogeneously arranged but tending to align themselves in a direction perpendicular to the panel surface. Particle length—$\frac{3}{8}$" to $\frac{1}{2}$" Particle width—$\frac{3}{16}$" Particle thickness—$\frac{1}{32}$" to $\frac{1}{8}$"	Hogged material produced from lumber and unbarked edgings. Particles aligned in planes parallel to panel surface. Range of particle size extremely varied and mixed. Particle length—$\frac{1}{8}$" to $\frac{1}{2}$" Particle width—$\frac{1}{16}$" to $\frac{1}{4}$" Particle thickness—$\frac{1}{32}$" to $\frac{1}{8}$"
Specific gravity*	0.68	0.61	High density board—0.73 Low density board—0.51
Moisture content	7%	7%	7%

*Specific gravity based on weight and volume in oven-dry condition.

Groups of specimens of each particle board were assembled into test joints aligned perpendicular and parallel to the main planes of particle alignment. Test groups of particle boards A and B were also prepared with cross-bands and face veneers on their surfaces to obtain information on the effect of veneering the board. Particle board C was supplied in two densities. This permitted a series of tests to determine the effect of density upon joint strength for boards alike in other respects.

Test material was also prepared using yellow poplar, a common lumber core material. Dowel joints were made in yellow poplar for the cross-grain and parallel-to-grain boring directions.

All particle boards, lumber, veneer, and dowels were conditioned to an equilibrium moisture content of 7 per cent for a period of at least 30 days prior to testing.

The dowel joints tested used $\frac{3}{8}$-inch diameter spiral grooved dowels (hard maple), fitted into holes $1\frac{1}{8}$ inches deep in $1\frac{1}{2}$ x $1\frac{1}{2}$ x $1\frac{1}{4}$-inch test specimens, to a depth of 1 inch. The joints were double spread with a typical polyvinyl resin emulsion adhesive. Dowel joints were permitted to cure from 7 to 12 days before testing.

Material for the test specimens was cut from flat panels. Panel thicknesses were $\frac{5}{8}$, 1, and $\frac{7}{8}$ inch for boards A, B, and C, respectively. Lamination was necessary to obtain stock of suitable thickness. This was done, using a cold liquid hide glue. In preparing the specimens, holes were located away from lamination glue lines in all cases except those bored perpendicular to the panel face. In those cases the hole did pierce a lamination glue line for boards A and C. The effect of such a glue line upon test results has not been studied. It is believed that this effect would be small because the glue lines were thin and did not permeate the particle board to any visible extent. Since these laminae were pierced at distances well below the specimen face ($\frac{5}{8}$ and $\frac{7}{8}$ inch) they are below the level of maximum stress and initial failure of the glued dowel joint.

For those interested in the possible effect of lamination upon test results, a check on density of the boards at their center as compared with the material near the surface showed the following results. The density of board A varied from 5 per cent above average near the surface to 5 per cent below average at the center. Board B was uniform in density. Density variation in board C was the same as that in board A. The test specimens did not fail in the laminations in any instance.

Veneer-faced specimens had a cross-band of 1/16 in. yellow birch and a face veneer of 1/32 in. mahogany. The veneer and cross-band were bonded together, and to the particle board, with cold liquid hide glue.

Holes were bored with a $\frac{3}{8}$-inch double spur machine bit. Dowels were selected to provide a dowel-hole diameter difference in the range of 1/64 to 1/32 inch. This assured a proper fit.[1]

On the basis of earlier testing of this type, a sample group size of five specimens was selected. At each rpm-feed speed classification there were five replications of the experiment. Very few specimens failed outside the test joint and the data for those was eliminated from the results.

For the yellow poplar, 120 test specimens were tested. For particle board A, 240 test specimens were used. For particle board B, 180 test specimens were used. For particle board C, 120 specimens were tested in the high density group and 30 specimens were tested in the low density group. A total of 690 specimens were broken.

Variables studied were rpm and chip thickness. Each joint investigated included specimens bored at three speeds (1620, 2880, and 4430 rpm) and four chip sizes (1/128, 1/64, 1/32, and 1/16 inch). Comparisons between particle boards, boring directions, and controls were made by t-tests. Analysis of variance was employed to determine significant effects of the machining variables. Detailed statistical results are not included in this report.

Specimens were broken on a Riehle 5000-pound universal testing machine, using a loading rate of 0.25 inch per minute.

Results are expressed in terms of breaking load for a $\frac{3}{8}$ inch diameter by 1-inch long dowel joint, rather than an average shear value in the glue line.

Tool RPM and Boring Chip Thickness

The test results obtained for the various particle boards, together with those for yellow poplar, are arranged in graphical form in Fig. 2 to facilitate comparison.

The low joint strength at 1/128-inch boring chip thickness for particle boards A and C are particularly notable. This is attributed to the cutting effect of the spurs at the low feed rates. Under these conditions the wood is evidently exposed to the greatest temperatures or temperature-time combinations. No similar effect is observed for particle board B. This may be due to the more open structure of the board, the larger voids possibly allowing the tool to operate at lower temperature.

The yellow poplar data displays reduced joint strength at similar, very low, feed speeds (1/128-inch chip

[1] Nearn, W. T., N. A. Norton, and W. K. Murphey. 1953. The strength of dowel joints as affected by hole size and type of dowel. Jour. of FPRS III (4):14-17, 72.

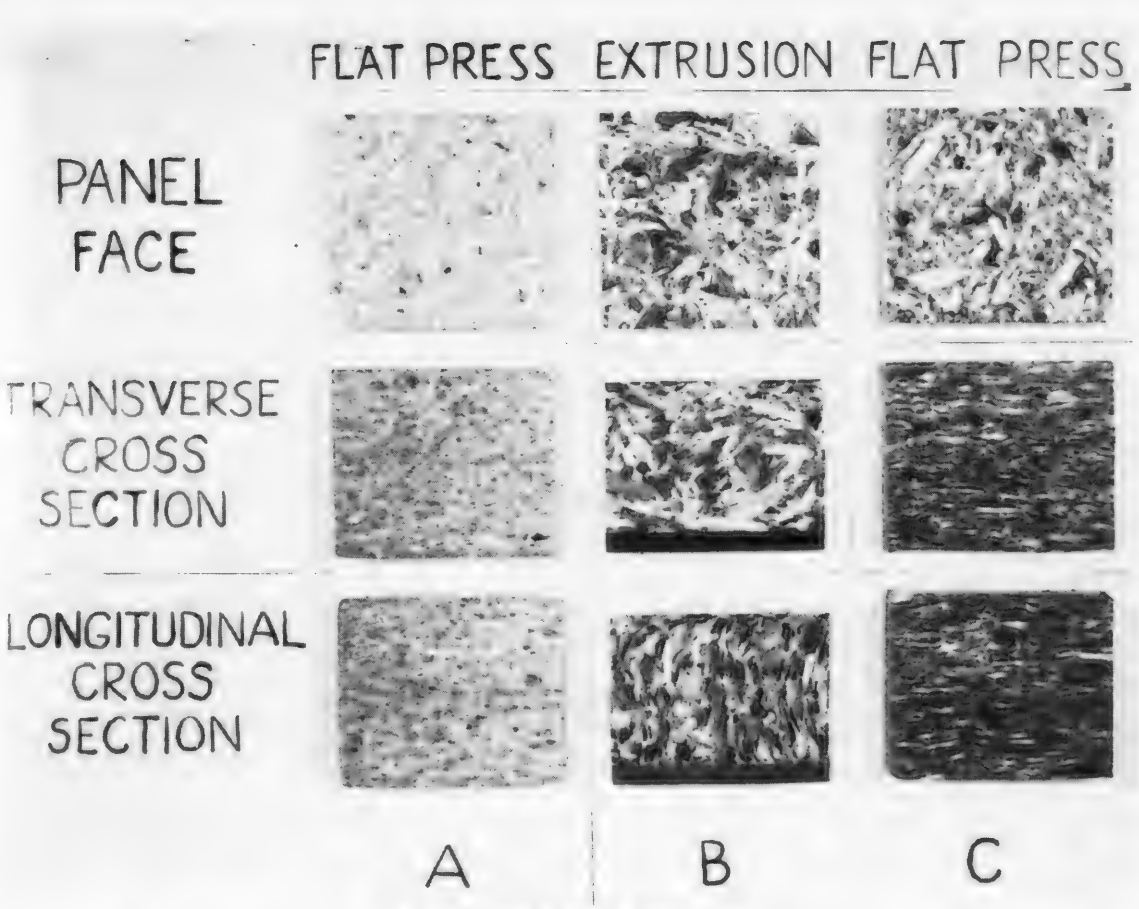

Fig. 1.—Structure of particle boards tested.

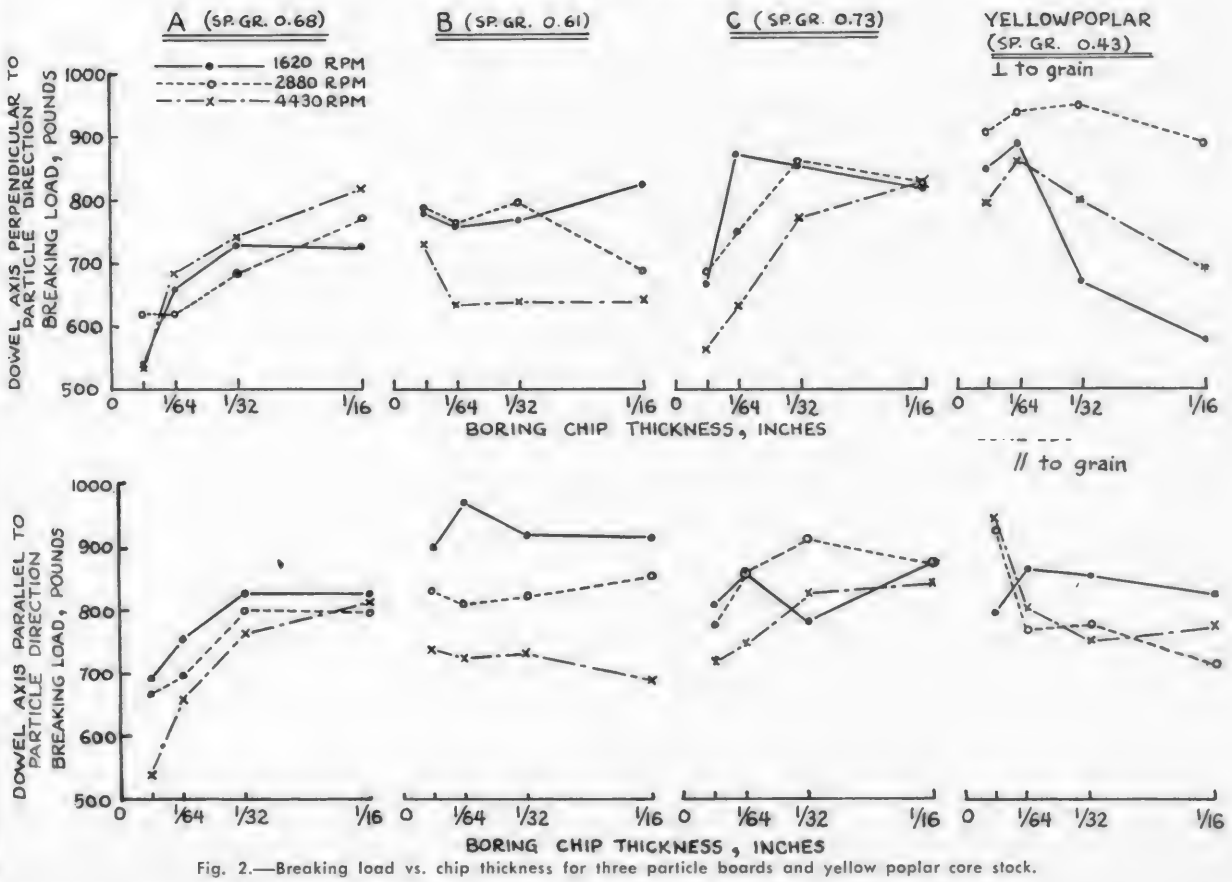

Fig. 2.—Breaking load vs. chip thickness for three particle boards and yellow poplar core stock.

Table 2.—DOWEL JOINT STRENGTH AT OPTIMUM BORING CONDITIONS

Type of Board	A, Flat-pressed	B, Ex-truded	C, Flat-pressed
Joint Strength, lbs.			
(a) Parallel to plane of particles	835	925	915
(b) Perpendicular to plane of particles	730	800	860

thickness) when bored across the grain. When bored parallel to the grain, a detrimental effect of low feed rate is noted at 1620 rpm only. The marked increase of joint strength at 1/128-inch chip thickness for yellow poplar bored parallel to the grain at 2880 and 4430 rpm may indicate low spur temperatures, due to ease of fiber separation, combined with low contact time between fibers and tool.

The general picture presented by these results would indicate that tool speeds of 1620 and 2880 rpm, combined with chip thicknesses of 1/32-inch, represent suitable operating conditions for the production of strong dowel joints in particle boards of the type used in these experiments. The most important result is the indication of a detrimental effect of small chip thickness upon joint strength for particle boards. A similar result was obtained in earlier tests using hard maple and red oak solid wood specimens.[4]

An outstanding difference between the particle board tests and the earlier work on solid wood was the good strength values developed at 1/16-inch chip thickness. An explanation of this difference is the possibility that the small particle components of the boards limit the fiber length and reduce the flexural strength of the board. The energy required to break the particle board shavings into chips and eject them from the cutting edges may be reduced, and the tool heating thereby minimized. In any event, tool feeds in particle boards may be somewhat greater than those used in machining solid wood.

Effect of Particle Board Density upon Dowel Joint Strength

Dowel joint strength was greater for high density board than for low density board. Particle board C was obtained in two densities. The particle size and species were alike in these two boards, but the high density type had a specific gravity of 0.73 whereas the low density type had a specific gravity of 0.51. The strength of joints bored perpendicular to the panel face at 2880 rpm for boring chip thicknesses of 1/64, 1/32, and 1/16-inch showed mean values of 815 lbs. and 428 lbs. for the high and low density samples, respectively.

The specific gravities of boards A and B were 0.68 and 0.61. The dowel joint strengths for these specimens showed mean values, for joints bored perpendicular to the plane of particle alignment, of 680 and 757 lbs. respectively for boards A and B. These two values are in the region between the two joint strengths given above for board C. The fact that the lower density board, B, exhibited greater joint strength is probably due to the large size particles of strong species, as compared to the small size particles of ponderosa pine in board A.

Relationship Between Dowel Joint Strength and Particle Direction

Dowel joints exhibited maximum strength when the axis of the dowel was located in the plane of particle alignment. Data supporting this conclusion is presented in Table 2.

Effect of Face Veneer on Dowel Joint Strength

The results presented in Fig. 2 represent the strength of dowel joints in holes bored in particle boards without face veneers. Since particle boards would ordinarily be veneered, the strength of joints in veneered particle board is of interest. Samples of particle boards A and B were faced with 1/32-inch mahogany veneer. A 1/16-inch cross-band of birch veneer was used in each case.

Since board A was a flat-pressed product, the plane of chip alignment was parallel to the panel face and perpendicular to the dowel axis. In the case of board B, an extruded product, the plane of chip alignment was perpendicular to the panel face and parallel to the dowel axis.

The dowel joint strengths for the veneered boards were greater in each case than the joints made in unveneered board. These differences were significant at the 1 per cent level, according to t-tests used in the analysis. The mean strengths for joints bored at 1620 and 2880 rpm, and at 1/64, 1/32, and 1/16-inch boring chip thicknesses are presented in Table 3.

The particle board materials displayed a tendency to crumble at the lip of the hole when tension was applied to the test specimens. A stress

[4] See footnote 1

Table 3.—DOWEL JOINT STRENGTHS AT OPTIMUM BORING CONDITIONS FOR PLAIN AND VENEERED PARTICLE BOARD

Type of Board	A, Flat-pressed	B, Extruded
Joint strength, lbs.		
Veneer faced	793	997
Plain	700	858

analysis indicates that maximum stress occur in this area of the joint. Since the particle boards have lower tensile and bending strength properties than normal wood, this type of behavior is expected. However, the veneer provided improved mechanical properties at the hole lip resulting in improved joint strength.

It is particularly interesting to note that the dowel joint strength for yellow poplar, a common core stock material, had a mean value of 870 lb. This indicates that particle board materials can be fully equivalent to solid lumber core materials in dowel joint strength perpendicular to the panel face, when faced with veneer and cross-bands.

Conclusions

1. A tool rpm of 2880 resulted in particle board dowel joints having superior strength to those bored at the other speeds used in this study. A suitable rpm range for ⅜-inch diameter holes is considered to be 2500 to 3000 rpm.

2. Feed rates to produce a boring chip thickness of 1/32 inch were most appropriate for particle boards. A 1/16-inch chip thickness was also acceptable. The feed rates may evidently be slightly higher for particle board than for solid wood. The consistent low strength of joints bored at feed rates to produce a 1/128-inch chip thickness was notable.

3. Dowel joint strength in particle boards was found to be highest when the dowel axis was in a plane parallel to the direction of particle alignment.

4. Particle board density was directly related to dowel joint strength. Tests on boards of equal particle characteristics but available in different densities provided information supporting this conclusion.

5. Veneered surfaces materially improved dowel joint strength in particle boards. Veneer provides improved strength properties at the panel surface in the area of greatest stress in the glue line. Dowel joints in veneered particle boards had strengths comparable to dowel joints in solid yellow popular lumber.

The Ideal Glue—How Close Are We?[1]

DON BROUSE

Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

Reviews developments in adhesives for woodworking since 1900, their present status, and what may be expected in the reasonably near future. Characteristics of an ideal glue are listed and an optimistic view taken that many of these characteristics may be developed in the future.

NO UNUSUAL POWERS are needed to predict that adhesives will become increasingly important to the wood-using industry. We may be growing wood as fast as we are cutting it, but in sawtimbers and high-grade veneer logs, we are certainly using basic capital as well as yearly increment. Of the hardwoods in the East in 1953, 10 per cent were high-grade logs, about 16 per cent medium-grade logs, about 54 per cent low-grade logs, and about 20 per cent were cull trees (17).[3] The percentage of the standing timber volume that would make high-grade logs declined in the Lake States from 1936 to 1953 about as follows: sugar maple, 26 to 18 per cent; yellow birch, 36 to 15 per cent; oaks, 16 to 12 per cent; and basswood, 29 to 21 per cent.

In Mississippi, for every 100 pines and other softwoods 20 inches and over in 1935, there were 58 in 1948. In the East, 78 per cent of sawtimber volume is in trees under 20 inches in diameter. The necessity of drawing more and more of our wood supply from smaller trees means greater use of adhesives in fabricating wood products of desired size and strength from the smaller pieces.

A prediction of greater use of adhesives in the future should not disregard the fact that adhesives are already of great importance to parts of the woodworking industry. In the fourth quarter of 1955, for example, something in the neighborhood of 300 million square feet of hardwood plywood was produced (20). For the year 1955, the production of Douglas-fir and other West Coast softwood plywood (16) topped 4 billion square feet (surface measurement) on a 3/8-inch basis. Based on these plywood production figures, a conservative estimate would be that something over 200 million pounds of adhesives (dry basis) were used in 1955 by the plywood industry alone.

Since the role of adhesives in woodworking is already big and promising to become bigger, it may be quite worthwhile to take a general view of the field of adhesives in woodworking—what has been the progress in the past, what is the present status, and what may be expected in the reasonably near future.

Animal Glues

In 1900, the woodworker had but one type of glue, animal, that was readily available commercially and that had been thoroughly proven in use. Today, some 10 distinct types are available together with several compositions that are essentially mixtures of different types. It may be of interest to review briefly these developments in woodworking glues during the last 50 years with the thought that such a review may indicate a probable course of developments in the future.

Animal glues are the oldest type of woodworking adhesives, and records of their use go back at least to the time of construction of the pyramids in Egypt (3). Animal glues are still in common use and are satisfactory for many uses. Like other glues that have survived in the competition of commercial use, they are capable of producing, when properly applied, excellent dry bonds in wood.

Animal glues' limitations are a lack of water resistance and certain operating characteristics. For the most part, they are applied in the form of a warm solution and the initial set takes place as a result of cooling. Permissible assembly periods vary sharply with temperature of the wood and working area and with grade of glue and concentration of mixtures (18). Consequently, the conventional animal glues that are applied warm are not readily adaptable to those operations in which the assembly time must vary within each item or batch, as in the production of plywood or in the fabrication of large laminated items. These limitations may account in part for the fact that the big increases in the production of plywood and glued laminated structural members did not take place until after other glues were developed.

The development of reliable liquid hide glues reduced or eliminated some of the disadvantages of the animal glues that were used warm, but by the time liquid animal glues were available commercially, other glues had gained a large share of the market.

First Starch Adhesive

In about 1903, F. G. Perkins developed a practical woodworking glue from starch (11). He found that tapioca starch seemed the most suitable for the purpose, and much of the starch glue used in this country was of tapioca starch from the Dutch East Indies.

For some purposes, the starch glue developed by Perkins was a distinct improvement over the animal glues. Although it was heated, usually in a mild caustic soda solution to convert the starch, it was cooled before use and applied at room temperature. Its operating characteristics were not changed significantly by those changes in temperature commonly occurring in woodworking shops, and assembly periods could vary over comparatively wide ranges, at least from less than 1 minute to more than 30 minutes, without significant effect on the quality of the glue bond. This wide range in permissible assembly periods was of distinct importance in the production of plywood. It permitted the development of procedures that greatly increased the speed of production and marked the development of plywood manufacturing as a separate division of the woodworking industry.

From about 1903 to World War I, a greater part of the plywood produced in the United States was probably bonded with starch glues. Its most important limitations, however,

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[1] Presented at meeting of FPRS Northeast Section, April 19–20, 1956, in Springfield, Mass.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to literature cited.

The Author: Don Brouse holds degrees from Purdue University and the University of Wisconsin. He taught at Baker University and served as Lt. Col. in the Air Force from 1942–46, in charge of group responsible for specifications for wood, glue, and glued wood products for aircraft. Research engineer at the Forest Products Laboratory since 1923, Dr. Brouse is now Assistant Chief, Division of Timber Processing.

were a lack of moisture and water resistance and an alkaline reaction that stained some species of wood.

Casein, Blood Albumin

The period of World War I marked the development of casein glues and, to a lesser degree in this country, blood glues. The demand for water-resistant glues for bonding plywood, spars, and other wood parts of military aircraft no doubt accelerated the development.

Like the starch glues, casein glues are easy to mix and apply. They are mixed at room temperature and, in this country, are normally used at room temperature, although some formulations can be hot pressed. The bonds have a moderate degree of water resistance but they cannot withstand indefinitely repeated wetting and drying or prolonged exposure to the weather or to an atmosphere sufficiently damp to permit mold growth. However, if the moisture content of the wood adjacent to the glue joint does not rise repeatedly or continuously above some 18 to 20 per cent, well-made casein glue bonds may retain their original strength and quality over many years.

During and shortly after World War I, the U. S. Forest Products Laboratory worked on the development of adhesives based on blood albumin (8). While usable formulas and bonding techniques were developed by which bonds superior in water resistance to casein glues could be produced, the most highly resistant glues required hot pressing. The number of hot presses in the woodworking industry of the United States at that time was limited, and consequently blood glues were seldom used in the domestic plywood industry. They were used rather extensively, however, in Germany, Finland, and Russia. One of the formulas developed by the Forest Products Laboratory was reportedly used by the English firm, Venesta Ltd., during the 1920's in producing their most resistant type of plywood.

Seed Meal Glues

In the early 1920's, I. F. Laucks developed practical and inexpensive woodworking glues based on soybean meal. The formulation was based on the protein fraction of the soybean meal (12) and resembled rather closely the formulation of casein glues. Laucks developed the soybean glues with particular attention to the bonding of Douglas-fir veneer. For that species, as well as for other softwoods, the soybean glues have been very successful. They have been used primarily in producing plywood of container grade with hardwoods.

As glues for softwoods, the soybean bonds have characteristics that closely resemble those of casein glue bonds. They have a moderate degree of water resistance, but they will not withstand the more severe exposures such as prolonged exposure to the weather or to a damp atmosphere. The development of this inexpensive glue with its favorable operating characteristics marked the start of the huge expansion of the Douglas-fir plywood industry. Until about 1940, it was essentially the only type of glue used in fir plywood.

Other seed meals such as peanut and cottonseed can be used in place of soybean. At one time, an adhesive assumed to be basically a combination of peanut meal and casein was in production on a commercial scale. Its operating and bonding characteristics were favorable, but it did not retain its markets, probably because of changes in the trends of adhesive development.

In this same period from 1925 to 1940, considerable attention was given to improving the protein glues. In some cases, the efforts were successful. Combinations of soybean meal and blood albumin, for example, were formulated that were capable of producing bonds more water resistant than those made with straight soybean glue. No basically new types of adhesives, however, were developed in this country during that period, and the attention of the investigators began to turn to other basic materials for adhesives.

First Phenol-Formaldehyde Resin

In some of his early patents, Dr. Baekeland (1) described the formulation and use of a phenol-formaldehyde resin as an adhesive for bonding. Apparently the market for molding powders based on phenol resins was much more promising than the market for woodworking glues. Consequently, the use of phenol resins for wood bonding was not pushed at that time.

In the early 1930's, the regulated economy in Germany diverted casein, the most popular glue base of that period, to uses other than glue and produced a pricing system that permitted bringing synthetic-resin glues onto the market at a price that could be tolerated for woodworking. The firm of T. Goldschmidt brought on the market a phenol- or phenol-cresol formaldehyde resin for wood gluing.

The Goldschmidt glue that gained first attention in the United States was in the form of a dry film consisting essentially of a partially reacted phenol-formaldehyde resin carried on a thin, porous paper. This film glue required a temperature of about 300° F. to complete the proper curing. This comparatively high temperature necessitated hot presses and consequently limited the use to thin plywood. To the plywood manufacturers in Europe, however, the use of hot presses for bonding was not uncommon. Consequently, they accepted the requirements more readily than plywood producers in this country, where hot pressing of plywood was rarely done at that time.

In spite of this handicap, a group (15) secured the right to market the Goldschmidt film phenolic glue, Tego, in this country. Shortly after its introduction, the Resinous Products and Chemical Co., Philadelphia, Pa., secured the rights and installed the equipment to produce Tego.

Bonds produced by phenol resin glues, when properly used, are very resistant to water and various other liquids, to attack by micro-organisms, to high temperatures, and have proved repeatedly more resistant to extreme exposure than the wood itself (4). For the first time in the history of woodworking adhesives, therefore, a glue was available that was capable of producing bonds that could be relied upon to withstand any service conditions that the wood itself could withstand. This development obviously broadened greatly the potential uses of plywood and particularly structural plywood. The development of the stressed-skin unit for prefabricated housing, for example, would have been greatly retarded except for the availability of adhesives capable of producing bonds in the plywood that were reliable under all conditions of service.

Following closely after the introduction of phenol-resin glue in film form, several of the resin producers developed and marketed phenol-resin glues in liquid form or as dry powders that could be suspended or dissolved in water or in alcohol-water mixtures. The forms that could be applied as liquids by conventional spreaders proved to be more popular than the film. At the present time, the film glue is used primarily for bonding thin or highly figured veneers.

The liquid types, however, gained wide acceptance by the plywood producers in the Pacific Northwest. This acceptance brought to the open market a type of plywood that could be depended upon to serve well under severe conditions of use. The availability of such highly resistant plywood increased public confidence in the product and, consequently, greatly increased the use of plywood for purposes requiring highly durable bonding. In 1956, for example, the production of the highly resistant or Exterior type of softwood plywood

amo ited to almost 1½ billion square feet in the United States and some 830 illion square feet in B. C.

troduction of Urea Resins

Sh rtly after the introduction of phe l-resin glues, the I. G. Farbenindu rie introduced in Germany a syntl tic glue based on urea-formaldehyd resin. The glue consisted essentially of the condensation product of urea nd formaldehyde. The reaction was topped at a stage in which the resin could be suspended or dissolved in water and the final curing completed in the bond under heat and pressure. The advantages of the early urea-resin glues over the phenol-resin glues were somewhat lower curing temperatures, a colorless glue line, and possibly lower price. The Casein Company of America, later absorbed by Borden, introduced the urea-resin glues in this country.

The next step was the development of catalysts that accelerated the urea-formaldehyde reaction to a degree that permitted curing at room temperature. By the beginning of World War II, several companies were producing urea-resin glues of both the hot-setting and room-temperature-setting types.

The urea-resin glues have found a large market in the hardwood plywood and furniture fields. In 1955, some 88 million pounds of urea- and melamine-resin glues were used in the plywood industry. For the same year, the consumption of phenol-resin glues was 36 million pounds (9). The urea-resin glue line is almost colorless, and resins formulated to set at room temperature will set rapidly at mildly elevated temperatures (about 10 minutes at 145° F., for example). They respond well to curing by high frequency heating. In many applications, the curing time could thus be reduced to a matter of seconds by the use of suitably designed circuits and jigs.

These resins can be extended to reduce costs with little decrease in dry joint strength, and they are sufficiently durable to give good service in domestic furniture, architectural wall panels, and similar interior uses. Urea bonded joints are not considered sufficiently durable to withstand prolonged exposure to the weather or to temperatures much beyond the human comfort range (21).

Development of Melamine Resins

The next type of adhesive to be developed for woodworking was the melamine-formaldehyde resin that was introduced by CIBA (Chemical Industries of Basel). In chemical structure, melamine resembles urea, and when formulated for glues for wood, melamine resin has some similarity to urea resin of the hot-press type. The differences, however, are probably of greater importance than the similarities.

Melamine-resin glues require comparatively high curing temperatures, they are more costly, and so far no room-temperature-setting formulation has been found that is acceptable for general use in woodworking. On the other hand, melamine-resin glue bonds are very resistant to severe conditions of service. In severe laboratory tests, however, it is possible to show that phenol-resin bonds are more resistant than those made with melamine-resin glues, and limited tests have indicated that melamine-resin glues do not bond preservative-treated veneers as well as phenol-resin glues. For many purposes, though, they may be considered equal to the phenol glues in durability.

Presumably because of costs and operating characteristics, the straight melamine-resin glues have not found wide use in the woodworking field. Melamine resins are compatible with urea resins, however, and the two can be mixed in any proportion. These melamine-urea blends have proved useful for fabricating glued products that require more resistant glue bonds than can be provided by straight urea-resin glues.

Resorcinal Resins

In about 1943, the Pennsylvania Coal Products Co., later absorbed by Koppers Co., began offering a woodworking glue based on resorcinol resin. Resorcinol is one of the dihydric phenols, and is more reactive than the mono-hydric phenols and cresols used in preparing the adhesives that we commonly term phenol glues. Resorcinol-resin glues, consequently, can be cured at room temperature to a degree that is sufficient for many purposes, and they require only moderately elevated temperatures to bond laminates of even the denser species for structures that will be fully exposed to the weather (19). The main disadvantages are cost and the lack of curing below about 70° F. The resorcinol resins can be blended with phenol resins and, consequently, the cost item can be reduced somewhat for those fabrication procedures in which the higher curing temperatures required by the straight phenols cannot be tolerated.

Use of Polyvinyl Resins

At about the end of World War II, the supply of animal glue became limited and polyvinyl-resin glues were offered to the woodworking industry as a substitute. In many respects, these polyvinyl glues are very suitable for woodworking, particularly for certain assembly operations in furniture fabrication. They produce a colorless glue line, they are marketed as a ready-to-use emulsion, the working life is indefinitely long, they set quickly, their resistance to moisture exceeds that of animal glue to some extent, and since they are only slightly acid they do not stain significantly. They have disadvantages, however, that should be considered before deciding on use (10).

All the other synthetic-resin glues discussed so far are of the thermosetting type that, once properly cured, remain firm and rigid even though the temperature of the glue bond may be raised above the curing temperature of the glue. The polyvinyl resins, however, belong to the thermoplastic group that does not set to a permanently firm, rigid condition, but yields slightly under continuous stresses below failing load. Consequently, they are not entirely suitable for use in bonds that are constantly under stress and where a firm bond of high strength and resistance to creep is essential.

In other uses, such as dowel and mortise-and-tenon joints, this flexibility seems to be an advantage. In tests of dowel and mortise-and-tenon joints exposed to conditions similar to those expected of furniture in normal domestic use, the polyvinyl glues performed better than other glues commonly used for assembly joints in furniture (14). The desirability of reducing or controlling the creep characteristics has been recognized, and some of the producers of polyvinyl glues are attempting to improve their polyvinyls by compounding them with thermosetting resins that will increase the rigidity of the glue joint.

Improving Quality

Throughout the development of woodworking glues, many attempts have been made to improve the glues by eliminating or reducing the effect of some objectionable characteristics. Some of these attempts were to:

1. Increase the resistance of animal glues to water and micro-organisms by the addition of preservatives and tanning agents (5).
2. Increase resistance of casein glue and soybean glue to micro-organisms by the addition of preservatives (7).
3. Increase the water resistance of casein and soybean glues by formulating with blood albumin.
4. Improve the working characteristics of urea-resin glues by the addition of fillers such as walnut-shell flour.
5. Accelerate the cure of phenol- and urea-resin glues by the use of acid catalysts.

While several of these attempts to improve the characteristics of a certain type of glue have been successful,

the improvement has been one of degree only, and the fundamental characteristics have remained as limiting factors. However, the blending of two types of glue, such as phenol and polyvinyl, and the development of new types of resins appear to offer greater promise.

The adhesives now available for bonding metal to metal illustrate some of the possibilities of improving adhesives by combining different types of resins. For several years, casein-rubber latex combinations had been used for bonding metal sheet materials to wood. Although the bonds were strong enough for many purposes, they were not strong enough to be considered adequate for structural units in which the strength of the bond was critical.

Recent Developments

In the early 1940's, however, adhesives and bonding processes were developed that, when properly used, produced bonds of high strength and durability between sheet metal and porous materials. Since that time, several other resins and bonding processes have been developed for the adhesive bonding of metal to metal and to other materials. Nearly all of the current adhesives for metal bonding are based on the combination of elastomers or thermosplastic resins to reduce stress concentration and thermosetting resins to provide the desired rigidity and resistance for the glue bonds. Some of the current combinations are vinyl-phenolic, neoprene-phenolic, and nitrile rubber-phenolic.

The bonding of metals involves the preparation of the surface of the metal beyond merely removing dirt, grease, and other foreign materials. More or less standardized procedures for preparing aluminum surfaces for adhesive bonding have been developed (6). For other metals, such as magnesium, titanium, and stainless steel, further investigations are needed, and these investigations may disclose some of the unknown characteristics or fundamentals of adhesion that may find future application to woodworking glues.

A desirable characteristic of adhesives for metals is that they be 100 per cent reactive so that no solvent or liquid or gaseous products of reaction must be removed after the adhesive is spread on the metal. While this characteristic is of less importance in bonding wood than in bonding metals, there are operations in wood bonding that could be improved if the bonding process caused no change in the moisture content of the wood.

The development in recent years of new polyester resins for glass fabric laminates and of epoxy resins for coatings were of considerable interest to the adhesive industry because these resin systems were in liquid form for convenient spreading, but the solvents reacted chemically with the resin without the evolution of by-products. The epoxy resins have so far proved much more promising as wood adhesives than have presently available polyester resins.

These epoxy resins are generally reaction products of bisphenol and epichlorohydrin, and are prepared for adhesive use by incorporating certain amines as curing agents (2). These epoxy-resin adhesives can be produced as readily spread liquids capable of curing at 70° F. or higher. Pot lives are generally short but progress in the use of newer amine curing agents has extended pot lives somewhat. Because no solvents or volatile by-products are released in curing, these adhesives do not require the high bonding pressures commonly used in wood gluing. They do not, however, normally possess high tackiness characteristic of contact-setting adhesives. Epoxy resins can be combined with other resins such as certain polyamide resins or phenol resins. They can also be combined with various fillers to modify their properties.

Straight epoxy resins are relatively colorless, soluble in organic solvents before curing, more expensive than other resins at present, and generally tend to retain a certain amount of thermoplasticity at elevated temperatures although the resins with proper curing agents are potentially thermosetting. Perhaps their outstanding property as an adhesive is a high degree of adhesion to a variety of materials including wood, metals, plastics, and glass. They do not have outstanding moisture and water resistance, and their other durability characteristics have not yet been adequately investigated. They have found important applications in bonding metal for aircraft, but at present they seem to show no outstanding advantages for bonding wood to wood. Their high cost and other limitations cited further limit their present consideration in this field. They have been used to a considerable extent for laminating impreg for die models for the auto industry (13).

Another field that appears to offer possibilities in improving the techniques of wood bonding is in contact-setting adhesives. Within recent years, many patents have been granted for contact-setting and pressure-sensitive adhesives. While many of these have been directed toward the packaging field, some have been directed toward the bonding of such wood products as insulation board or acoustical tile in the building field.

The asphalt mastics and rubber-base adhesives for bonding wood and linoleum floors may be considered as contact-bonding-cements, and the bonding of plastic table tops to a plywood base is often done with contact adhesives. Equipment is available commercially to provide roller pressure for this operation of bonding decorative surfacing to wood faces. If successful, the advantages are obvious because it would permit converting to a continuous operation in place of a batch process.

While the few tests made at the Forest Products Laboratory have indicated that none of these contact adhesives now available is capable of producing bonds that are strong, rigid, and durable enough to serve for the gluing of stressed members, it does appear that some of them are very near the stage where they could be used to apply overlays on wood surfaces by rapid, economical procedures. When such a procedure can be demonstrated to be reliable, important advances in the use of paper-base overlays for lumber and plywood can be predicted without hesitation. Further, if a contact pressure adhesive capable of producing strong, durable bonds under roller pressure only can be developed, the impact will be felt strongly in the prefabricated housing industry, because it would permit a sharp reduction in the labor costs and time of fabricating the building units.

Characteristics of an Ideal Glue

A listing of all the desirable characteristics of an ideal glue for woodworking may be very disappointing because no one type of glue available at present meets all the requirements by any means, and because the list will show characteristics that appear mutually exclusive in the light of our present knowledge. It must be recognized, however, that two characteristics, indefinite working life and rapid setting, that seemed mutually exclusive have in a measure been provided in the polyvinyl glues. The same end result of a quick cure combined with favorable working characteristics has also been provided by taking advantage of the properties of high-frequency circuits for rapidly raising the temperature at the glue line.

The possibility of developing better catalysts that will remain stable at ordinary temperatures and become active at slightly elevated temperatures has not been thoroughly investigated.

A study of the basic properties that a glue must have and constant attention to developments in other related fields are promising steps to aid the

chemists in the development of improved adhesives.

It is encouraging to recall that many of the glues now commonplace would have been considered impossible by the knowledge available in 1900, for example. This survey of the progress in woodworking adhesives since 1900 should justify an optimistic and rather well grounded hope that many of the characteristics desired but not now available in current glues will be developed, and in a shorter time than the more conservative of us may think.

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The Effect of Swelling Agents and Catalysts on Acetylation of Wood[1]

L. P. CLERMONT and F. BENDER

Ottawa Laboratory, Forest Products Laboratories of Canada, Division of the Forestry Branch, Department of Northern Affairs and National Resources, Ottawa, Ontario

Preliminary studies were made of suitable conditions for acetylation of sawdust. Then veneers were esterified by a vapor phase technique using three modifications. Dimensional stability was improved in all cases and work with other stabilizing agents is in progress.

IN A RECENT ARTICLE, Thomas (1)[2] describes a new method for the activation and acetylation of cellulose which involves impregnating cellulose with certain combinations of urea with other compounds, drying, and esterifying with acetic anhydride at elevated temperatures. Triacetates with unusually high degrees of polymerization (D.P.) are produced very rapidly by this method.

Another rapid method for the acetylation of cellulose is described by Blume and Sweezey (2). This method uses the system, acetic anhydride—potassium acetate as acetylating medium and dialkylamides such as dimethyl formamide (D.M.F.), or gamma lactones as the reaction medium. Products obtained by this method also have a high molecular weight.

Various investigators have subjected wood to acetylating treatments. In all cases where an acid catalyst such as sulphuric acid is used, serious degradation, i.e., loss of strength, occurs. Hess (3) found that pyridine-swollen wood could be readily acetylated with a solution of acetic anhydride in pyridine. The resulting material was undegraded and had a high acetyl content. These findings by Hess form the basis of the work of Stamm and co-workers (4). Stamm acetylated wood in a vapor atmosphere of pyridine and acetic anhydride. The treated material has a greatly increased dimensional stability.

The anti-shrink effect of acetylating and other esterifying treatments of wood is based on the fact that by these treatments some of the hydrophilic hydroxyl groups of cellulose and lignin are replaced by more bulky and less hydrophilic groups. The increase in bulk keeps the wood in a permanently swollen state and is at present generally considered the more important of the two factors. The importance of Thomas' (1) findings for acetylation of wood lies in the fact that the use of both sulphuric acid and pyridine can be avoided. Whereas sulphuric acid is most objectionable on account of its degrading effect on wood, pyridine is rather expensive and presents some health hazards.

During the summer of 1954, some preliminary (unpublished) experiments (8) were carried out at the Ottawa Forest Products Laboratory in which black spruce sawdust was acetylated under various conditions. The aim of these preliminary experiments was to establish optimum conditions for acetylation of wood.

Factors investigated were: temperature, amount of impregnation, moisture content, effect of catalyst used, and effect of acetic anhydride

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The Authors: L. P. Clermont received chemical engineering degree from McGill University and M. S. from New York State College of Forestry, Syracuse. He has been engaged in research in wood chemistry for the past nine years at the Ottawa Laboratory.

F. Bender holds Doctor's degree from Technical University, Darmstadt, Germany. He did post doctoral work at Heidelberg University before coming to Canada in 1940. Dr. Bender has been connected with the Ottawa Laboratory since 1942 and is now Head of the Wood Chemistry Section.

Table 1.—EFFECT OF REACTION TEMPERATURE ON ACETYLATION (LIQUID MEDIUM) OF UREA-IMPREGNATED SAWDUST (BLACK SPRUCE)

Temp. °C.	Time (min.) After Induction Period	Induction Period (min.)	Total time (min.)	Acetyl %
85	35	15	50	30.0
95	10	15	25	31.0
115	3	15	18	32.3
125	1	15	16	32.1
138	0	15	15	32.7

concentration in the acetylating medium. In some cases, D.M.F. was used as the acetylating medium.

After having established by these preliminary studies suitable conditions of reaction, the sawdust was replaced by veneers of black spruce, white birch, and poplar. By choosing relatively thin sections (not thicker than 1/8 inch the problem of penetration with urea and salt impregnants was eliminated. The impregnated veneers were found to be readily treatable in the liquid and in the vapor phase, yielding products with high acetyl contents, and good mechanical properties.

After having established conditions for simple and efficient methods of acetylating veneers, some further work was carried out with bulking reagents other than acetic anhydride. Phenylisocyanate is known to react with cellulose under certain conditions. Schnaebeli (5) claims to have reacted the free hydroxyl groups of cellulose with phenylisocyanate in the presence of pyridine. The final reaction product is cellulose-triphenyl-carbamate. Reaction times were 12–14 hours at 80–100°C.

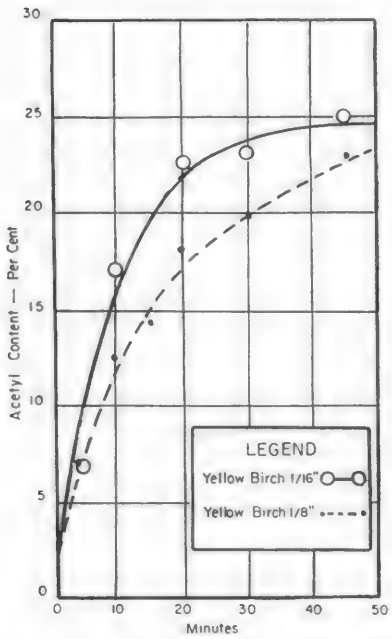

Fig. 1.—Rate of acetylation in the vapor phase of yellow birch veneers at 138° C.

The general reaction can be expressed as follows:

$$R{-}N = CO + R^1OH \rightarrow RNHC = O \quad (OR^1)$$

Both liquid phase and vapor phase treatments of veneers impregnated with D.M.F. were carried out.

Experimental Part

a) Preliminary Experiments on the Rapid Acetylation of Sawdust (Liquid Phase)

Black spruce sawdust of 40–60 mesh size was used throughout this investigation. Impregnation was carried out simply by letting the sawdust soak for about 30 minutes in a solution containing urea "impregnant" and ammonium sulphate "catalyst", filtering off the excess solution, and drying at 105° C. In all experiments, unless otherwise reported, 5 g. samples of dry sawdust were suspended in 125 ml. acetylating medium. The reaction flasks were equipped with reflux condensers. The acetyl content was determined by the method of Eberstadt (6) and by the method of Phillips (7) in a slightly modified form.

Reaction Variables: The variables included temperatue of acetylation, amount of catalyst—impregnant in the wood, moisture content, type of catalyst, and amount of acetic anhydride used.

Temperature: The temperature range studied varied from 85° C. to 138° C. In all cases, except at 138° C. when the reaction was instantaneous, an induction period was observed varying from 1 min. at 125° C. to 35 min. at 85° C. In order to achieve the same degree of acetylation (about 32 per cent acetyl groups), 15 min. were required at 138° C., 50 min. at 85° C. Results are listed in Table 1 and Fig. 1.

Amount of Catalyst—Impregnant in the Wood: The sawdust was soaked in urea-ammonium sulphate solutions of various concentrations, dried, and the per cent weight increase determined. It was found that a 15 per cent retention of catalyst-impregnant by the wood was sufficient to give maximum acetylation under the conditions studied.

Moisture Content: Impregnated sawdust of moisture contents varying from 10 to 150 per cent was acetylated in the liquid phase at 125° C. for 1 hr. Results indicated that under these conditions the initial moisture content had no effect on the degree of acetylation. Results are listed in Table 2.

Table 2.—EFFECT OF MOISTURE CONTENT ON ACETYLATION (LIQUID MEDIUM) OF UREA-IMPREGNATED SAWDUST*

Induction Period (sec.)	Moisture Content %	Acetyl %
18	10	30.6
15	15	30.7
0	30	31.9
0	50	31.5
0	100	31.6
0	150	31.7

*Reaction time: 1 hr. Temp. 125°C. Acetic Anhydride used: 125 ml.

Effect of the Salt Component (Catalyst) of the Impregnating Solution: The sawdust was impregnated with solutions of urea, containing salts of weak and strong acids. These included: ammonium sulphate, ammonium chloride, sodium acetate, zinc chloride. The acetylation was carried out at 125° C. for 40 min. using for each 5 g. of sawdust 0.5 g. of catalyst. Of all impregnants tried, the urea-ammonium sulphate combination was found to be the most effective. This parallels the findings of Thomas (1) with cellulose.

Effect of Concentration of Acetic Anhydride in Acetylating Medium: Impregnated sawdust was treated in a mixture of acetic anhydride with an inert solvent such as toluene. The anhydride concentration in the solution varied from 85 per cent to 3 per cent; the reaction was carried out at 110° C. for 1 hr. It was found that anhydride to wood ratios greater than 8:1 did not affect the degree of acetylation appreciably. Below this value, the acetyl contents decreased rapidly. Results are listed in Table 3.

Acetylations (Liquid Phase) Using Dimethylformamide as Reaction Medium

The function of urea in the above described acetylations is not clearly understood. It is known that urea is a good swelling agent for cellulose and wood. This property might be sufficient to explain the remarkable ease of acetylation after urea impregnation. Another compound which also

Table 3.—EFFECT OF ACETIC ANHYDRIDE CONCENTRATION IN ACETYLATING MEDIUM ON ACETYL CONTENT (LIQUID MEDIUM)*

Composition of Solution			
Acetic Anhydride (ml.)	Toluene (ml.)	Reflux Temp. °C.	Acetyl
125	25	127	[illegible]
60	90	113	[illegible]
30	120	110	[illegible]
15	135	110	[illegible]
10	140	110	[illegible]
5	145	110	[illegible]

*Reaction time: 1 hr.

swells wood to a considerable degree is D.M.F. A number of acetylations were carried out, using this compound as reaction medium.

Effect of Temperature: The reaction mixture consisted of 1 part D.M.F. and 4 parts acetic anhydride, to which 1 g. of ammonium sulphate was added as catalyst. The temperatures ranged from 95° to 144° C. Reaction time was 1 hr. It was found that below 135° C., acetylation proceeds rather slowly in this medium. Results are listed in Table 4.

Effect of Various Salts on the Degree of Acetylation: The reaction mixture consisted of a 50 per cent solution of D.M.F. in acetic anhydride to which different salts were added as catalysts. Refluxing was continued for 1 hr. at 150° C. Results indicated that ammonium sulphate was by far the best catalyst although potassium acetate also gave good results. Results are listed in Table 5.

b) Dimensional Stabilization of Veneers by Vapor Phase Treatments with Acetic Anhydride and Phenyl Isocyanate

Sampling: Sheets of yellow birch, aspen poplar, and white spruce veneers, 1/16 and 1/8 inch thick, were cut into strips 1 inch wide and 3 inches long. The strips were numbered and specimens from adjacent sections of the same veneer sheet were used so as to avoid as much as possible, variations due to differences in content of springwood and summerwood.

Vapor Phase Acetylation of Urea-Ammonium Sulphate Impregnated Veneer Strips

The specimens, 1/8 inch in thickness, were placed in a suction flask and impregnated with a solution containing 38 per cent urea and 2 per cent ammonium sulphate. The flask was evacuated for about 10 minutes and the vacuum then released. This treatment was repeated a few times for a total impregnation time of about 30 min. The samples were dried in an oven at 105° C.

For the reaction rate studies at the boiling point of the acetic anhydride (138°C.), the strips were simply attached to a piece of nichrome wire and suspended in a wide mouth two-liter round bottom flask. The treated samples were washed in hot water, dried, ground in a Wiley mill, washed again with hot water until free of acid, dried, and the acetyl contents determined by a modified Phillips (7) method.

For the bulk acetylation of a large number of samples to be tested for volumetric swelling and flexural strength, a glass reaction vessel was used in which ten samples could be suspended at one time and treated for 1 hr. The vessel was immersed in an oil bath kept at 105° C. Results are listed in Tables 6 and 7.

Vapor Phase Acetylation of Potassium Acetate Impregnated Veneer Strips

Strips of 1/8 inch thickness were vacuum impregnated with aqueous solutions of potassium acetate and dried at 105° C. Acetylation was carried out in a glass vessel by suspending the impregnated samples over mixtures of D.M.F. and acetic anhydride. The vessel was immersed in a constant temperature oil bath kept at 125° C. Treatment lasted 2 hrs. Results are listed in Tables 8 and 9.

Vapor Phase Treatment with Phenylisocyanate

The 1/8-inch thick samples were impregnated with D.M.F. under vacuum for 30 min. at room tem-

Table 4.—EFFECT OF TEMPERATURE ON ACETYLATION REACTION IN DIMETHYLFORMAMIDE (LIQUID MEDIUM) *

Catalyst	Temp. °C.	Acetyl %
Ammonium Sulphate	144	32.4
Ammonium Sulphate	135	33.5
Ammonium Sulphate	125	18.0
Ammonium Sulphate	109	17.2
Ammonium Sulphate	95	10.1
None	135	16.3
None	109	15.4

*Reaction time: 1 hr. Ratio: D.M.F.: acetic anhydride 1:4, catalyst added: 1 gm.

Table 5.—EFFECT OF VARIOUS SALTS ON THE DEGREE OF ACETYLATION IN DIMETHYLFORMAMIDE *

Catalyst	Time	Acetyl %
Potassium Acetate	1 hr.	27.9
Sodium Acetate	1 hr.	24.5
Ammonium Sulphate	15 min.	34.3
Potassium Acetate	15 min.	19.8

*Reaction Temp.: 150°C. D.M.F.: acetic anhydride ratio 1:1, catalyst added: 25 gm.

Table 6.—VOLUMETRIC CHANGES IN ACETYLATED SPRUCE, POPLAR, AND BIRCH VENEERS *

Property	Birch		Poplar		Spruce	
	Acetylated	Control	Acetylated	Control	Acetylated	Control
Acetyl %	20.8		28.2		21.6	
O.D. volume before acetylation c.c.		5.76		6.22		5.48
O.D. volume after acetylation c.c.	6.50		6.76		6.35	
Water-swollen volume c.c.	6.89	6.86	6.94	6.94	6.55	6.25
Volume change c.c.	0.39	1.10	0.18	0.72	0.20	0.77
Anti-shrink efficiency %	68.5		76.7		77.3	

*Acetylated in the vapor phase after urea—$(NH_4)_2SO_4$ impregnation.

Table 8.—ACETYLATION OF POTASSIUM ACETATE-IMPREGNATED VENEERS IN VAPOR PHASE OVER DIMETHYLFORMAMIDE AND ACETIC ANHYDRIDE FOR 2 HOURS AT 125° C.

Species	Acetylating Medium			A.E. %
	D.M.F. %	Acetic Anhydride %	% KAc in Solution	
Spruce	50	50		43.6
	50	50	4	69.0
	50	50	10	73.6
	25	75	4	48.6
	25	75	10	72.3
Poplar	50	50		21.5
	50	50	4	46.3
	50	50	10	63.0
	25	75	4	46.3
	25	75	10	44.1
Birch	50	50		37.7
	50	50	4	46.0
	50	50	10	60.0
	25	75	4	52.8
	25	75	10	53.4

Table 7.—SPECIFIC GRAVITY AND FLEXURAL STRENGTH OF ACETYLATED SPRUCE, POPLAR AND BIRCH VENEERS *

	Spruce		Poplar		Birch	
	Acetylated	Control	Acetylated	Control	Acetylated	Control
Acetyl content %	19.3		20.3		16.0	
Specific Gravity	0.45	0.37	0.54	0.45	0.70	0.62
Modulus of Rupture lbs/in²	6870	11970	10480	14470	15780	21875

*Acetylation in the vapor phase of urea—$(NH_4)_2SO_4$ impregnated veneer over acetic anhydride at 105°C. for 1 hour.

Table 9.—PROPERTIES OF VENEERS ACETYLATED IN THE VAPOR PHASE WITH 50% D.M.F.—50% ACETIC ANHYDRIDE MIXTURE *

	Acetyl %	Anti-Shrink Efficiency %	M. of R.	
			Controls	Treated Samples
Spruce	20.6	73.6	11970	9740
Poplar	17.3	63.0	14470	15680
Birch	14.2	60.0	21800	22100

*Treated at 125°C. for 2 hrs. Impregnant: 10% KAc solution.

perature. The impregnated samples were then suspended in a glass vessel containing about 15 mls. of phenylisocyanate and placed in an oil bath at 100° C. for various periods of time. The treated samples were washed with D.M.F., water, acetone, and dried at 105° C. Results are listed in Table 10.

Volumetric Swelling and Flexural Strength Determinations of Treated Samples

The swelling measurements involved the determination of the oven-dry volumes of the veneer samples and the water-swollen volumes after a 24 hr. immersion period. The anti-shrink efficiency (A.E.) was determined thus:

$$\% \text{ AE} = \frac{\% \text{ swelling of control} - \% \text{ swelling of treated sample}}{\% \text{ swelling of control}}$$

The flexural strength tests were carried out on samples 1/8 inch thick, 1 inch wide, and 5 inches long. The specimens were tested over a 3-inch span under center loading at no load machine speed of 0.052 inch per minute.

Discussion of Results

Acetylations of sawdust impregnated with urea and a catalyst proceed smoothly at temperatures lower than reported so far in literature for acetylations of cellulose. The figures in Table 1 show that acetyl values obtained at 85° C. are not far below the maximum obtainable at 138° C. Moisture content of the wood has not been found to be critical under the experimental conditions used (Table 2).

Acetylations can be carried out effectively in a toluene solution of acetic anhydride as long as the ratio acetic anhydride to toluene is not lower than 1 to 4 (by volume); below this ratio, the acetyl contents fall off sharply (Table 3).

D.M.F. offers some advantages as a swelling agent in acetylations. Being liquid and miscible with acetic anhydride, it can be used in a one-step procedure. Temperatures required, however, are higher than in the case of urea impregnation, for corresponding degrees of acetylation (Table 4).

Of the various salts which were tried as catalysts, only ammonium sulphate and potassium acetate were found to be very effective (Table 5).

Table 10.—VAPOR PHASE TREATMENT OF D.M.F. — IMPREGNATED VENEERS WITH PHENYLISOCYANATE

	Time of Treatment (hrs.)	Temp. °C.	A.E. %
Spruce	1	100	66.3
Poplar	1	100	27.0
	1	125	59.8
	2	125	77.3
Birch	1	100	0
	1	125	22.4
	2	125	69.0

Treatment of veneers in liquid media by the above techniques is possible. However, vapor phase treatments seem to be more practical for veneers. The anti-shrink efficiency produced by acetylations carried out in the vapor phase on spruce, poplar, and birch veneers is shown in Table 6; the rate of acetylation in the vapor phase is shown in Fig. 1.

The increases in specific gravities of vapor phase—acetylated veneers of spruce, poplar, and birch (shown in Table 7), are greater than those reported by Tarkow, Stamm and Erickson (4) for similar acetyl contents. The reason for this might be some retention of urea, in spite of extensive washing. The figures for the modulus of rupture (also shown in Table 7), show an appreciable loss of strength.

Potassium acetate impregnation, if followed by vapor phase treatment of an acetic anhydride—D.M.F. mixture proved quite effective with regard to dimensional stabilization (as shown in Table 8), especially with spruce veneers. Whereas the urea-ammonium sulphate impregnated veneers after vapor phase acetylation with acetic anhydride show appreciable (up to 40 per cent) loss of strength, vapor phase treatments of veneers (impregnated with 10 per cent potassium acetate solution) over a mixture of D.M.F. and acetic anhydride resulted in high anti-shrink efficiencies and no loss in strength. The observed values for M. of R. of treated poplar and birch veneers were 3–6 per cent higher than those of controls. This treatment was equally efficient with all species investigated. (Results are listed in Table 9.)

In addition to acetylation studies, a series of experiments with phenylisocyanate is also reported. Veneers swollen in D.M.F. and exposed to vapors of phenylisocyanate for 1–2 hrs. at 100–125° C. showed high (up to 77 per cent) anti-shrink efficiency. (Results are shown in Table 10.) All phenylisocyanate vapor-treated veneers showed increased mechanical strength over controls. The treated veneers appeared unchanged in color. Work with other bulking agents is in progress and will be reported in a later publication.

Summary

After preliminary studies of the conditions for the acetylation of sawdust, veneers were esterified by a vapor phase technique using the following three modifications:

1. Veneers impregnated with a urea-ammonium sulphate solution, dried, and exposed to acetic anhydride vapor.
2. Veneers impregnated with a potassium acetate solution, dried, and exposed to vapors of a mixture of D.M.F. and acetic anhydride.
3. Veneers impregnated with D.M.F. and exposed to vapors of phenylisocyanate.

In all cases dimensional stability was improved. Work with other stabilizing agents is in progress.

Veneers with acetyl contents over 30 per cent and anti-shrink efficiencies over 70 per cent were produced by methods 1 and 2.

Veneers with anti-shrink efficiencies over 70 per cent and slightly increased strength (3–6 per cent increase in M. of R.) were obtained by method 3.

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Retail Marketing of Charcoal in Iowa[1]

J. G. YOHO and V. L. ROBINSON

Associate Professor and Research Assistant, Department of Forestry, Iowa State College, Ames, Iowa

Consumer purchases of charcoal from retailers in Iowa exceeded one-half pound per person (considerably below some national estimates) during 1955, an increase of two-tenths of a pound over the previous year. Per capita sales varied greatly in marketing areas in different population classes. One type of retail outlet (grocery stores) and one size of bag (10 pound) dominated the marketing picture. In a general way, the results of this study probably are applicable to most sectors of the U. S.

Introduction

WITHIN THE LAST FEW YEARS considerable interest has been exhibited in forestry and forest product circles over the possibility of disposing of low grade hardwoods or hardwood manufacturing wastes by converting such material into charcoal. This interest has been particularly keen in the hardwood regions of the United States where the margin of profitability of timber harvesting and forest management frequently depends upon the ability to break even on the removal of the poorer grades and more undesirable species. As a matter of fact, so much has been said about this problem of low grade hardwood utilization that there is scarcely a forester or forest industrialist who is not aware of the seriousness of this situation as it affects the total forest economy of the nation. This hardwood utilization problem has actually been many years in evolution but interest in the subject has been greatly accelerated in recent years with the publication of each new forest resource report.

Commensurate with the attention created by the forest resource reports were two other trends which have been responsible for focusing research interest on charcoal as a partial solution to the problem described above. One of these has been the decline of the hardwood distillation industry which produced most of America's charcoal as a by-product to the manufacture of such things as acetone, methanol, acetic acid, tars, wood oils, etc. The other trend has been associated with consumer behavior and has often been summarized by the phrase, "outdoor living". Few of us have failed to realize that millions have taken up the art of preparing, or the habit of eating, charcoal-broiled meats. The natural result of these rather obvious trends has been the concentration of research and manufacturing interests in the production of charcoal.

On closer examination, however, many facets of this apparent partial solution to the low grade hardwood utilization problem are not quite so obvious. In fact, some of the most fundamental questions of that phase of economics called marketing are lacking all but hearsay answers. Some of these elementary questions would be: Is the actual consumer demand as defined by economists increasing or not? What is consumer preference with respect to types of charcoal, style of charcoal containers, type of retail outlet, size of package, etc.? What is the structure of the retail market for charcoal and its total size?

These are simple questions but they are examples of the basic questions which need to be answered before sensible or efficient production or distribution policies can be formulated. Moreover, such answers should be available to intelligently guide research in charcoal production. Likewise, these are the guide posts entrepreneurs demand before they can be induced to expand old or enter new avenues of production or distribution.

In order to answer most of these and other questions concerning the marketing of charcoal at the retail level, the Iowa Agricultural Experiment Station with the assistance of Bankhead–Jones federal marketing funds undertook a study of the 1955 retail markets for charcoal in Iowa. The actual survey was conducted during the latter part of 1955 and the early part of 1956.[2]

Although the results of this study relate directly to Iowa only, the degree to which the results would apply elsewhere might logically be expected to depend upon similarities in the urban-rural population distribution, the level and distribution of per capita personal income, and the importance of the outdoor recreational industry in the local economy. In terms of the ratio of urban to rural population, the 1950 census ranked Iowa 33rd in the nation with 47.7 per cent of the population classed as urban; for the nation as a whole the figure was 64 per cent urban. Iowa ranked 29th among the states in per capita personal income in 1955 with a figure of $1,577, some $270 below the national average.[3] Generally, recreational industries are poorly developed in the state.

The role of population distribution was explored in considerable detail in this study but the income and recreational factors were not. It was noted, however, that charcoal sales tended to run highest in communities assumed to have the largest proportion of middle class families. Likewise, high per capita sales were observed in those sectors of the state which are characterized by outdoor recreational activities but sufficient data were not obtained to make valid statistical comparisons.

Study Procedure

As previously described, this study of charcoal marketing was confined to the retail level. This particular level was chosen because it is the best point to learn something about consumer reaction as well as other factors related to total consumption, supply and demand, etc. In order to facilitate this work a sampling scheme was devised in cooperation with the Statistical Laboratory at Iowa State College.

In sampling it was elected to use individual cities as the sampling unit

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[1] Journal Paper No. J-3063, Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1287.

The Authors: James G. Yoho holds B.S. from University of Georgia, M.F. from State University of New York College of Forestry, Ph.D. from Michigan State University. Formerly on the faculty at Stephen F. Austin State College, Nacogdoches, Texas, he currently specializes on work in forest economics.

Vernon L. Robinson holds B.S. from Iowa State College and is a candidate to receive M.S. in forest economics in July 1957. Employed as a research assistant, he is conducting two marketing studies—one the basis for this article and the other a lumber marketing study in Iowa.

[2] All of the data presented in this article refer to the year 1955 unless specified as being related to the previous year, 1954.

[3] Schwartz, Chas. F. and Robert E. Graham, Jr. 1956. State income payments in 1955. Survey of Current Business. U. S. Bureau Commerce, Office of Business Economics. 36:8–12. Disposable income would be a better indicator but such a series is not readily available by states.

and to canvass all retail charcoal dealers in each city selected in the sample. Cities were stratified by population according to the 1950 census before those to be surveyed were chosen. This stratification and sampling was as follows:

Population group[4]	Total number of cities in state	Number of cities selected in sample
Over 25,000	13	4
10,000 25,000	10	4
5,000 10,000	28	4
1,000- 5,000	168	12
Under 1,000	710	12
Total	929	36

[4]Classes were more closely defined as: 25,000 and over; 10,000 to 24,999; 5,000 to 9,999; 1,000 to 4,999; and 999 or below.

Within this scheme the rural population of the state was assumed evenly distributed with respect to preference for marketing and hence was distributed equally among all cities regardless of size.

Total volume of charcoal sold, which is assumed equal to total consumption, was estimated by the ratio estimator technique.[5] For example, the total adjusted population in cities over 25,000 was computed as 757,019. Charcoal sold in the four cities sampled in this stratum totaled 155,909 pounds for the year 1955 while their population totaled 196,357. Thus, the total volume sold in this particular stratum was estimated as $\frac{757,019}{196,357} \times 155,909 = 601,082$ pounds.

Total amounts sold or consumption for the other population strata were estimated in the same fashion and totals for all strata summed to obtain a total of 1,461,399 pounds for the state. When tested statistically this estimate was found to be within 7.7 per cent of the actual with a probability of two out of three.

Population of Marketing Area Affects Sales

Most observers would expect charcoal sales per capita to be lower in the rural marketing areas than in the more urbanized centers where the trend toward outdoor living apparently has been more pronounced. This generalization was confirmed by the study as indicated by Table 1. The fact that dealers in urban marketing areas over 5,000 in population with 43 per cent of the potential buyers sold 70 per cent of all charcoal in the state clearly demonstrates the point.

The peak in per capita sales in the 5,000–10,000 population group was surprisingly high and is not easily explained. It is indeed striking that this class with only about 8 per cent of the marketing population accounted for 21 per cent of the sales (Table 1) and had per capita sales nearly double that of any other group. The explanation for these phenomena appears to be related to the distribution of per capita disposable incomes as well as to simply consumer preference.

The number of dealers handling charcoal per 1000 population conformed rather closely to the distribution of average per capita sales (Table 1) with the exception that the peak occurred in the 1,000–5,000 population group in one case and in the 5,000–10,000 group in the other case. The ratio of the number of dealers per 1000 population to per capita sales, however, was greatest in the smallest rural centers. Conversely, sales per dealer were greatest in the largest urban centers and least in the smallest rural areas.

Types of Retail Outlets and Dealership History

A charcoal producer attempting to sell directly to retailers or a wholesaler marketing charcoal would be very much interested in the type of retail establishment which might become his best customer. In order to provide this type of information, retailers handling charcoal were grouped into 11 convenient categories (Table 2).

The most important category was grocery stores which, with about 38 per cent of the dealerships, accounted for about one-third of the total volume sold. Three categories (grocery stores and both classes of hardware) accounted for two-thirds of the volume sold through 74 per cent of the dealers who handled charcoal.

In terms of the average volume sold per dealer within the different retail outlet categories, however, a different pattern appeared. Table 2 shows that five retail-outlet categories had dealers who averaged higher volume sales than dealers in the three outlet categories which headed the total sales ranking. Average sales per dealer were twice greater among fuel dealers than they were for any other type of outlet.

When types of outlets were ranked according to total sales by the population of the marketing area (Table 3) not much change in order was noted in the larger marketing centers. In centers over 10,000 in population, fuel dealers, retail mail order outlets, and drug stores were more important than they were in terms of the total market. Either first or second place ranking was held by grocery stores or independent hardware dealers in all marketing areas excepting those in the 5,000–10,000 population class.

Some types of outlets were typically large marketing center sellers and vice versa. For example, five of the outlet classes (grocery stores, retail mail order, fuel dealers, drug stores, and sporting goods) sold over half of their total volume (Table 3) in centers of over 25,000 population. Auto dealer and chain hardware establishments, on the other hand, made over 60 per cent of their sales in marketing areas under 5,000 in population. Some classes of outlets were virtually nonexistent in the small marketing areas.

The selling of charcoal was found to be a relatively new venture for most retailers but few new dealers appeared in the year immediately preceding the study. Over one-half of the dealers indicated that they had handled charcoal three years or less but only 4 per cent said that they had added charcoal to their line within the preceding year. The various periods of time that dealers indicated they had handled charcoal were as follows:

Number of years handled	Per cent of dealers	Per cent of volume sold
Under 1	4	[illegible]
2–3	51	[illegible]
4–5	19	[illegible]
6–9	13	21
10 and over	10	68
Undesignated	3	[illegible]
Total	100	100

A more detailed analysis by type of outlet indicated one striking deviation from the pattern shown above in the case of fuel and lumber dealers. Nearly one-half of the dealers in these two outlet categories said that they had handled charcoal for 10 years or more.

Can a dealer expect to increase his sales of charcoal the longer he carries it for sale? This is an important question for new dealers who may be disappointed with their first year's sales and to those who are considering selling it for the first time. A comparison between the last two columns in the tabulation above sheds some light on this question. Note, for example, that those who had handled charcoal three years or less (55 per cent of all dealers) sold only 25 per cent of the volume. The same type of comparison for other time periods seems to indicate, though less strikingly, that it does take time for a dealer to capture his share of the retail market.

Price Structure and Demand Analysis

The price per pound for charcoal asked by retailers was found to vary considerably. This price was found to vary more with the size of bag in which the charcoal was sold than any other factor. Average price per pound

[5]William G. Cochran. 1953. Sampling techniques. New York, John Wiley and Sons, p. 129.

Table 1.—CHARCOAL SOLD AND NUMBER OF RETAIL DEALERS HANDLING CHARCOAL BY POPULATION OF MARKETING AREA

Population of marketing area	Volume sold		Number of dealers	
	Total pounds	Average per capita	Total number	Per 1000 population
Over [illegible],000	601,082	0.794	463	0.612
10,000-25,000	124,276	0.765	127	0.775
5,000-10,000	304,017	1.457	338	1.619
1,000-5,000	340,774	0.667	883	1.728
Under 1,000	91,250	0.093	653	0.665
Total	1,461,399	0.558	2,464	0.940

Table 2.—CHARCOAL SOLD AND NUMBER OF DEALERS BY TYPE OF RETAIL OUTLET

Type of outlet	Volume		Dealers handling number
	Total pounds	Average per dealer	
Grocery stores	484,872	519	934
Independent hardware	313,129	521	604
Chain hardware	159,266	573	278
Retail mail order	33,708	1,558	22
Lumber dealers	187,594	913	205
Fuel dealers	85,726	3,817	22
Drug stores	34,663	998	35
Sporting goods	29,816	1,076	28
Auto supply	72,305	409	117
Auto dealers	48,147	449	107
Miscellaneous*	12,173	225	54
Total	1,461,399	593	2,466

*Includes feed dealers, hobby shops, etc.

Table 3.—CHARCOAL SOLD BY TYPE OF RETAIL OUTLET AND POPULATION OF MARKETING AREA

Type of outlet	Over 25,000	10,000–25,000	5,000–10,000	1,000–5,000	Under 1,000	Total
	Volume in thousand pounds					
Grocery stores	307	48	49	51	30	485
Independent hardware	71	28	81	109	24	313
Chain hardware	6	6	43	104	6	159
Retail mail order	33	1	†	†	†	34
Lumber dealers	27	10	96	40	15	188
Fuel dealers	73	13	†	†	†	86
Drug stores	32	2	†	†	†	34‡
Sporting goods	15	1	14	†	†	30
Auto supply	32	8	6	19	7	72
Auto dealers	3	5	10	15	15	48
Miscellaneous*	2	2	5	3	†	12
Total	601	124	304	341	91	1,461

*Includes feed dealers, hobby shops, etc.
†Less than 500 pounds.
‡Apparent discrepancy between this total and corresponding figure in Table 2 is due to rounding.

Table 4.—AVERAGE PRICE PER POUND OF CHARCOAL BY SIZE OF BAG AND TYPE OF RETAIL OUTLET

Size of bag	Type of retail outlet			Average
	Grocery stores	All hardware*	All other†	
	Dollars per pound			
2 pound	.24	[illegible]	.24	.24
5 pound	.12	.11	.14	.12
10 pound	.08	.10	.10	.10
Over 10 pound	.09	.12	.09	.09
Average‡	.10	.10	.11	.10

*Includes chain hardware, independent hardware, and sporting goods.
†Includes retail mail order, auto supply, fuel dealers, drug, lumber, auto dealers, and miscellaneous stores.
‡Computed by weighting according to the number of pounds sold.

(Table 4) ranged from 8 cents for the 10-pound bag to 24 cents for the two-pound bag. The range in price per pound by retail outlet, however, was not particularly significant.

The 10-pound bag was by far the most popular size having accounted for 75 per cent of the volume sold in 1955. No other size bag accounted for more than 16 per cent of the volume sold that year. Between 1954 and 1955 the popularity of the five-pound bag increased more rapidly than any other size, their sales having increased more than 15-fold between the two seasons. However, the sales of 10-pound bags increased greatest in terms of share of the total market.

It was not possible in a study of this design to draw valid conclusions concerning consumer reaction to the style and serviceability of the various media for packaging charcoal. On this point, however, dealers were rather free with their criticisms of the style packages most commonly used. For example most dealers thought packages needed to be made more attractive by the use of brighter colors. This suggestion was made most frequently by grocers and other dealers who make most of their sales to the housewife. Dealers also often suggested the need for a stronger package than the common paper bag.

Some indication concerning consumer preference for briquet versus lump charcoal also was sought through dealers' opinions. Over 90 per cent of those dealers willing to pass judgment on such a question flatly stated consumers wanted briquet type charcoal. The validity of this sweeping statement is, however, open to question on the grounds that few dealers had ever handled lump charcoal.

Retailers are always interested in the effect of a change in the price of a commodity upon sales and revenue. The results of this study did not permit broad conclusions to be drawn concerning that point because few price changes were recorded between 1954 and 1955. However, it is of interest to note that grocery stores which cut prices by about 29 per cent increased their share of the charcoal market from 8 per cent in 1954 to 27 per cent in 1955.

The dealers themselves differed in opinion regarding the advantages of cutting the price of charcoal as a means of increasing sales. Among those dealers who were willing to express themselves on this question, 57 per cent thought that a drop in price would not stimulate sales while the balance took the opposite point of view.

Most observers are well aware that the consumption of charcoal for domestic purposes is quite seasonal. Therefore, it is not surprising that this study indicated large seasonal fluctuations in retail sales. Some 60 per cent of the dealers indicated that their sales were limited to the period of June through September, 36 per cent said their sales extended from April through November, while only 4 per cent reported sales throughout the year.

Little variation in seasonality of sales was noted from one type of retail outlet to another with the possible exception of grocery stores. Six per cent of these stores reported sales throughout the year, whereas, 4 per cent was the average for all dealers. On the other hand, the sales of large-volume dealers appeared to be subjected to less exaggerated seasonal fluctuations than the smaller dealers. For example, 14 per cent of the volume was sold by that 4 per cent of the dealers reporting year-around sales and 41 per cent of the volume was sold by the 36 per cent of the dealers who reported their sales limited to the period of April through November.

One of the questions posed earlier in this article was related to the changes in consumer demand[6] for charcoal. This is probably the most important single question that a study of this type should attempt to answer. In all of the recent research into the production of charcoal it has been assumed quite hopefully on the basis of very little evidence that domestic demand for charcoal has been increasing. Fortunately, this study showed rather

[6] "Demand" is used throughout this paper according to the economic definition of the term. This definition states that demand is a schedule of the quantities of a commodity which will be purchased at a series of prices. Thus, a change in demand refers to a shift of the entire schedule. For example in the case of an increase in demand the demand curve shifts upward and to the right. For a more detailed explanation see any textbook on economic analysis or: Zivnuska, John A. 1955. Supply, demand, and the lumber market. Journal of Forestry. 53:547–553.

conclusively that this assumption is correct.

Between the years 1954 and 1955 it was found that total retail sales of charcoal in Iowa increased 160 per cent while average price remained constant at 10 cents per pound. In other words, a new point of equilibrium between supply and demand was reached at a higher rate of consumption without a change in price. This indicates that the demand curve shifted upward and to the right between 1954 and 1955 or, stated in another way, that the demand increased. Still another indication of the increase in demand for charcoal is the fact that per capita sales increased from 0.35 pounds per potential customer in 1954 to 0.56 pounds in 1955 while average prices remained unchanged.

The explanation for the apparently constant increase in demand for charcoal for domestic uses has already been explored to some extent in the introduction to this article. The trend toward outdoor living mentioned earlier is undoubtedly the most important explanation. Sales promotion campaigns by such people as charcoal broiler manufacturers and others have certainly played an important role in influencing this trend.

Comparison of Three Methods of Determining Whether Southern Pine Poles Are Well Air Seasoned

J. S. MATHEWSON and P. J. BERGER

Engineer, Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture; and Assistant Engineer, Cincinnati Gas and Electric Co., Cincinnati, Ohio

Data obtained with a resistance-type moisture meter were compared with megger or ohmmeter readings and with moisture content determinations made on increment borings 0.16 inch in diameter. The results showed that any of the three methods may be used to determine when southern pine poles are ready for preservative treatment.

Summary

A RESISTANCE TYPE of electric moisture meter and increment borings were used to determine the transverse moisture distribution in well air-seasoned Class 5, 40-foot southern pine poles which had an average diameter at groundline of 10.4 inches. An ohmmeter called a megger was used to determine the electrical resistance of the poles between two twentypenny nails driven 25 feet apart in each pole. At a depth of three-tenths of the radius, at which point the moisture content is theoretically the average transverse moisture content, the moisture meter readings corresponded very well with the average moisture content obtained by distillation of the borings.

When the moisture meter readings were between 20 and 30 per cent, the corresponding electrical resistance values obtained with the megger were in most cases between 2.5 and 3.5 megohms. Experience has shown that poles in this resistance range are ready for treatment with creosote.

Introduction

During the past 21 years, the Cincinnati Gas and Electric Co., Cincinnati, Ohio, has been purchasing southern pine poles in a wide range of areas. The poles for the tests reported in this paper came from Alabama and Georgia. They were machine peeled at the shipping point, immediately sprayed with a fungicide, shipped to Finney, Ohio, and air seasoned in the yard of a wood-preserving plant.

The power company has developed a method involving the use of a megger, or ohmmeter, to determine when the poles are dry enough not only for preservative treatment but also for the safety of linemen when they are working on poles with distribution wires carrying current at 5,000 volts.

Two twentypenny nails are driven about 3½ inches into the wood and 25 feet apart in a pole. When the megger connected with the two nails indicates a resistance of 500,000 ohms, the pole is considered ready for treatment.[3]

The purpose of the present investigation was to obtain data with a resistance-type moisture meter for comparison with megger readings and also for comparison with moisture content determinations made on increment borings 0.16 inch in diameter.

The field work was done during the period Sept. 12 to 16, 1955, except that one pole was tested on October 26, 1955.

Procedure

The poles were piled parallel to each other on treated timber foundations 2 feet above the ground, which was covered with cinders. The tops of the poles were placed at the north end of the piles with the object of reducing checking at the bolt holes and gains. The layers of poles were separated by three tiers of 6- by 8-inch, creosoted railroad crossties. The piles were about 20 feet wide and 18 feet high and were spaced 4 to 6 feet apart. The pile roofs were either galvanized corrugated steel or corrugated aluminum, with frame members of treated southern pine. Each roof consisted of three or four panels to facilitate handling by a locomotive crane. The general appearance of a row of piles is shown in Fig. 1, upper, except that the present practice is to support the piles about 2 feet above the ground (Fig. 1, lower).

Moisture meter readings and megger readings were taken on 17 Class 5, 40-foot southern pine poles 90 days after they were shipped and seasoned

[1] Presented at Session VII, Wood Drying, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C. A summary of the paper was given at the meeting by R. C. Rietz, U. S. Forest Products Laboratory, Madison, Wis.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The Authors: James S. Mathewson is a graduate of University of Cincinnati. An Engineer in the Division of Physics and Engineering at the Laboratory, he has conducted research in air seasoning of lumber, crossties, and poles; kiln drying of lumber; and lumber storage.

Paul J. Berger's first contact with Cincinnati Gas and Electric Co. was in 1928 as a cooperative electrical engineering student at U. of Cincinnati. Since 1933 he has been associated with pole laboratory research, and southern yellow pine pole production, conditioning, preservation, and inspection.

[3] Stewart, P. B. 1936. The electrical resistance of wood poles. Proc. of American Wood-Preservers' Assoc., pp. 353–385.

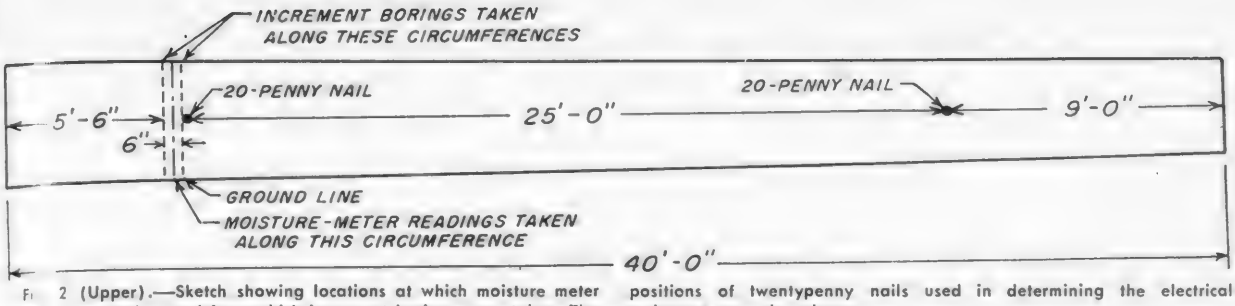


Fig. 2 (Upper).—Sketch showing locations at which moisture meter readings were taken and from which increment borings were taken. The positions of twentypenny nails used in determining the electrical resistance are also shown.

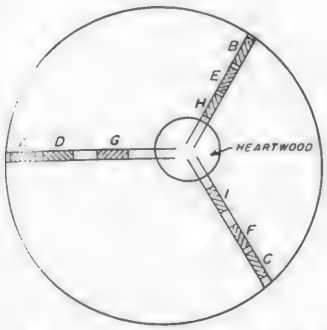


Fig. 2 (Lower).—Method of cutting increment borings into sections for determining moisture content distribution by distillation. Two similar sets of borings were taken 6 inches apart, one at the ground line and the other on the circumference 6 inches below the ground line. Three borings were taken 120° apart in each set. Sections A, B, and C taken at the ground line and 6 inches below the ground line were weighed together before and after distillation, as were sections D, E, and F, and sections G, H, and I.

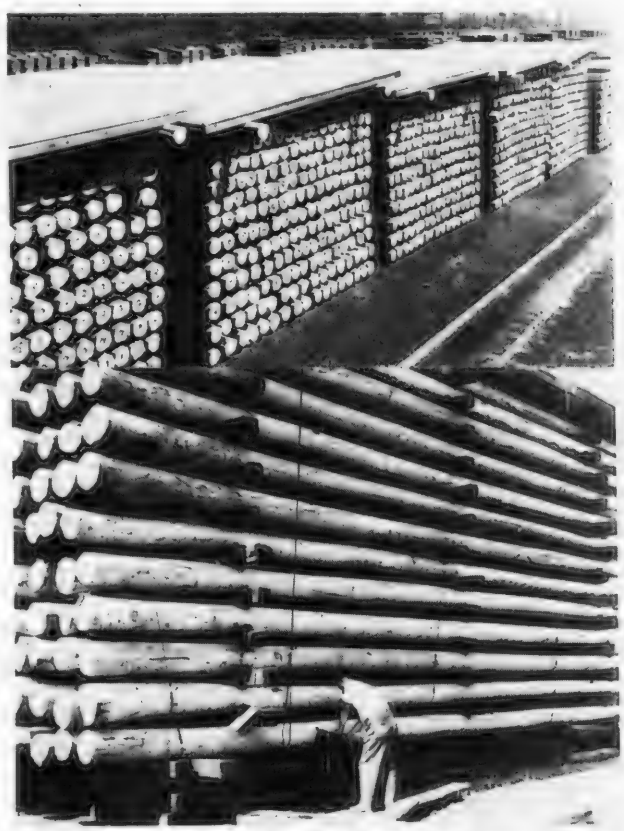


Fig. 1.—Method of piling southern pine poles. (Upper) Original piles had low foundations. (Lower) Present piles have high foundations to afford better circulation of air below the piles. Worker is using a megger, or ohmmeter, to determine the electrical resistance of a pole by means of wires extending from the megger to two twentypenny nails 25 feet apart in the pole.

quently stored in a yard at Finney, Ohio. Increment borings were taken from 12 of the 17 poles to determine moisture distribution.

Three increment borings were taken at points 120° apart around the ground line, 6 feet from the butt. Similar borings were taken around a circumference 6 inches below the ground line (Fig. 2, upper). The positions of the nails are also shown in Fig. 2. Each of the six borings was cut into three sections 1 inch long. One section (section D, E, or F, Fig. 2, lower) represented the "average inch," which is at a depth of three-tenths of the radius below the surface. The average transverse moisture content theoretically occurs at this point if the evaporable moisture remaining does not exceed four-tenths of the original evaporable moisture.[4] The second section (section A, B, or C, Fig. 2, lower) represents the 1-inch annular zone outside the "average inch" zone, and the third (section G, H, or I, Fig. 2, lower) represents the 1-inch annular zone in the middle of the sapwood zone on the pith side of the "average inch" zone (Fig. 2, lower). The corresponding sections of the six borings were weighed together and were used for the moisture content determinations for the respective zones by distillation with toluol.

Moisture meter readings were taken 120° apart on a circumference 3 inches below the ground line, or midway between the two circumferences around which the increment borings were taken (Fig. 2, upper). The moisture meter readings were taken successively at depths of ⅜ inch, 1 inch, 3/10 of the radius, and 2 inches.

Results

The two curves in Fig. 3 show the average transverse moisture distribution values for 12 poles, and are based on moisture meter readings with a species correction factor of plus 1 per cent (dashed line) and on moisture content values determined by distillation (solid line). The surface moisture content was estimated to be 11.3 per cent, based on Weather Bureau records of temperature and relative humidity at the Greater Cincinnati Airport for 5 days before the poles were tested. The airport is about 8 miles from the yard where the poles were air seasoned. The average temperature and relative humidity at the airport during the entire air-seasoning period were 75° F. and 68 per cent, respectively. These conditions correspond to an

[4] Matthewson, J. S. 1952. Air seasoning of lodgepole pine poles. U. S. Forest Products Laboratory Report 1922.

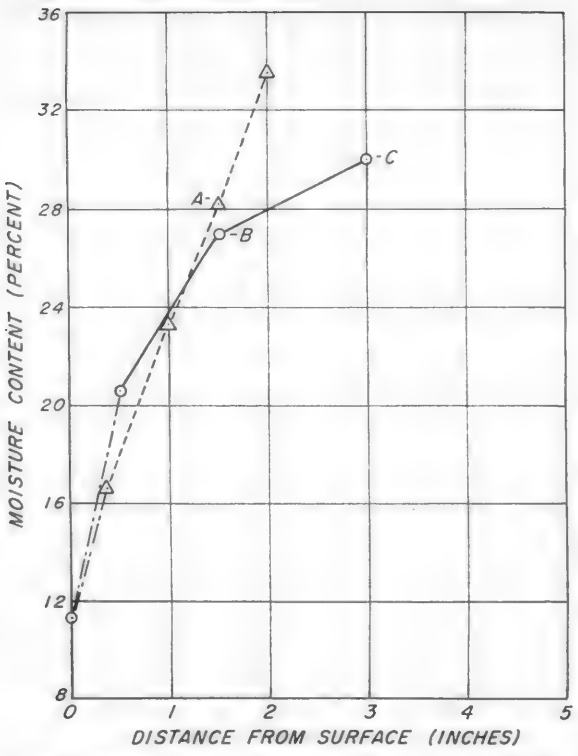


Fig. 3.—Average transverse moisture distribution curves for 12 Class 5, 40-foot southern pine poles. The dotted curve is based on moisture meter readings, and the solid curve is based on moisture content values determined by distillation. Point A corresponds theoretically to the average moisture content of the cross section determined by the moisture meter. Similarly, point B corresponds to the average moisture content determined by distillation.

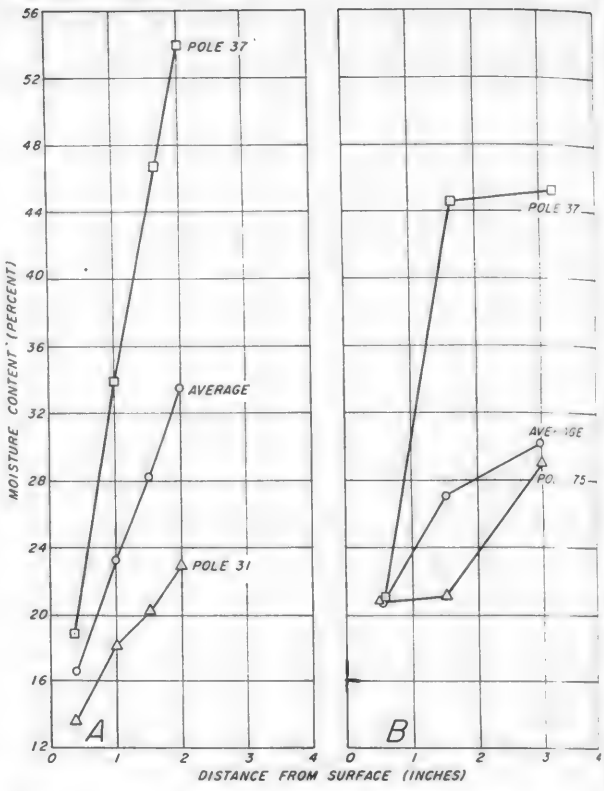


Fig. 4.—Average transverse moisture distribution curve and moisture distribution curves for the wettest and driest of 12 southern pine poles: A, based on moisture meter readings, and B, based on moisture content values determined by distillation.

equilibrium moisture content of 12.5 per cent.

The average transverse moisture distribution curve that is based on moisture meter readings in Fig. 3 is shown in Fig. 4A, together with moisture distribution curves for the wettest and driest poles. All three curves are based on moisture meter readings with a species correction factor of plus 1 per cent. Similar curves based on moisture content values determined by distillation are shown in Fig. 4B.

Fig. 5 is a plot showing the relationship of electrical resistance to moisture meter readings, while Fig. 6 shows the relationship of electrical resistance to moisture content values determined by distillation.

Discussion of Results

In Fig. 3, the dashed line represents the moisture distribution determined by the moisture meter readings and the solid curve shows the moisture distribution based on determinations by distillation. At the points A and B, 28.2 and 27.0 per cent are the theoretical average transverse moisture content values at or near the ground line. The average depth for these values is about 1½ inches below the surface of the poles. The moisture content at point C is somewhat lower than would be expected. The result is attributed to the fact that the six 1-inch sections from which the value for point C was determined were the last to be cut. Consequently, they may have dried appreciably before they were placed in test bottles and weighed.

The primary interest was in testing poles with an electrical resistance of about 2.5 to 3.5 megohms. Consequently, most of the comparative readings were taken on poles with such resistances. One pole had a resistance of 7 megohms, however, and the resistances of three other poles were only 0.03, 0.04, and 0.05 megohm. The three points corresponding to these values appear near the lower right-hand corner of Figs. 5 and 6. At these high moisture content values, the moisture meter readings are inherently less reliable than when the reading is less than 30 per cent. When wood is dried from a moisture content of 30 per cent to 0 per cent, the electrical resistance may increase a millionfold. When wood absorbs moisture from 30 per cent to a moisture content in some cases as high as 200 per cent, however, the decrease in electrical resistance is less than fiftyfold.

Since the company was interested primarily in testing poles with electrical resistances of 2.5 to 3.5 megohms, a variance analysis was made on the moisture meter readings and moisture content values determined by distillation for the "average-inch" zone. The analysis involved the data for 14 poles. The average of the moisture meter readings was 23.3 per cent, and the average of the moisture content determinations was 23.1 per cent. The respective standard deviations were 2.31 and 2.38. The difference between the results obtained by the two methods was thus found to be insignificant at the 5 per cent level

Conclusions

The results obtained with the moisture meter and with moisture content determinations by distillation were not statistically different at the 5 per cent level.

When the moisture meter readings are taken at a depth of three-tenths of the radius and range between 20 and 30 per cent, they correspond to megger readings of 2.5 to 3.8 megohms, or possibly up to 7 megohms when such readings are taken as described.

Thus, any of the three methods may be used to determine when Class 5, 40-foot southern pine poles are ready for preservative treatment.

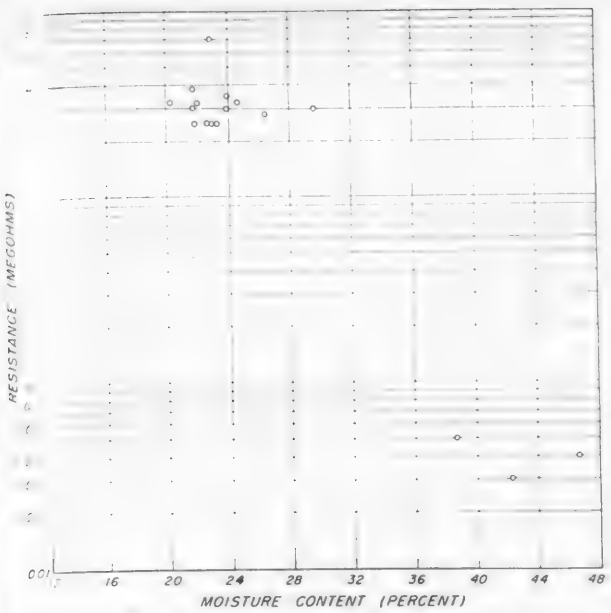


Fig. 5.—Plot of electrical resistance against moisture meter readings taken on 17 southern pine poles.

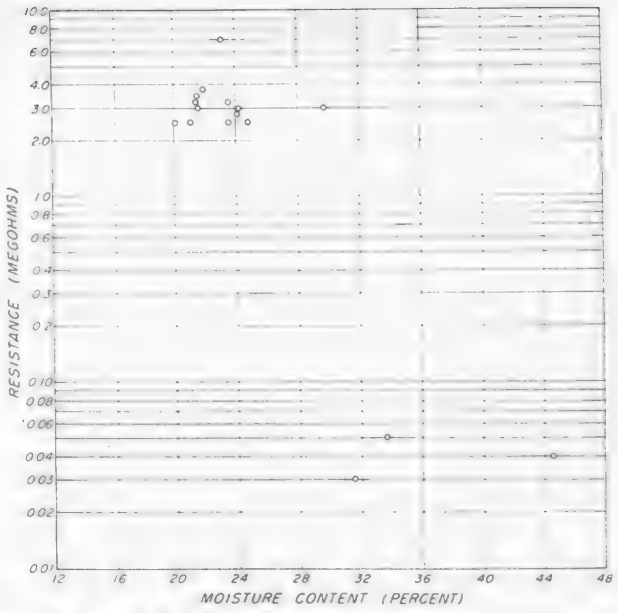


Fig. 6.—Plot of electrical resistance against moisture content values determined by distillation of increment borings from 16 southern pine poles.

Discussion

Fred Dickinson (University of California Forest Products Lab.): Can nails driven into wood be used successfully over a period of time as contacts for a moisture meter in making moisture content determination?

William J. Delmhorst (Delmhorst Instrument Co.): Nails can be used—with moisture meters to obtain an approximate measurement of moisture content. It must be borne in mind that the readings will tend to be higher than the actual moisture content of that part of the wood with which they make contact because nails have a greater electrode surface in contact with the wood and thus lower the effective resistance.

I believe that the amount of seasoning that has taken place in a pole or heavy timber can be more accurately determined by using contact pins which are insulated except at their points. With these it is possible to accurately measure moisture content at different distances from the surface of the wood and thus moisture gradient which is related to the degree of seasoning. Readings are usually made at ¼, ½, and 1 inch from the surface. Before any seasoning has taken place, all readings are high and there should be little differences between the three readings. Partly seasoned poles show considerable differences in readings and the greater the amount, the more severe are the drying conditions. Completely seasoned poles have a flat moisture gradient but the readings are of low value and approximately equal to the average e.m.c. conditions in the seasoning yard.

Mr. Mathewson: If nails are used, they should be of the same diameter as that of the pins of the electrode.

If nails are used for taking periodic readings with a moisture meter to determine the rate of drying, the readings may be too low because of the increased electrical resistance at the surfaces of the nails resulting from checking of the wood at the nails.

Mark Lehrbas (Southern Forest Experiment Station): In the south if poles are permitted to season until well air dried for treating, deterioration generally occurs. We need to know more about protecting the poles from decay fungi during the seasoning period.

Effect of Final Steaming on Distribution and Permanence of Pentachlorophenol in Air-Seasoned Southern Yellow Pine Pole Sections Pressure Treated with Penta-chlorophenol-Petroleum

W. C. KELSO, JR. and E. A. BEHR

Wood Technologist and Manager, Technical Dept., Chapman Chemical Co., Memphis, Tenn.

Data are presented to show the effect of final steaming on the distribution and permanence of pentachlorophenol and its solvent in air-seasoned southern pine pole sections pressure treated by the empty-cell method. A statistical comparison of the results indicated that the final steaming periods employed produced no significant difference in the gradients either immediately after steaming or following storage in a horizontal position for 4 months.

Introduction

THE EFFECT of after-treatment conditioning methods on the preservative gradient in pressure treated wood products has increased in importance in recent years. The emphasis being placed on cleanliness of the treated wood is the primary reason for the growing importance of such conditioning methods. With the possible exception of crossties, nearly all wood items currently being pressure treated with either creosote or oil-borne preservatives are required to pass certain cleanliness standards. In many instances treating plant operators have found it necessary to use some type of final conditioning to meet these standards. The latter has been especially true for wood impregnated with the foregoing preservatives following either air- or kiln-drying. Although a number of conditioning methods are being used at the present time, the practice of steaming following preservative impregnation has received the most widespread attention.

Although final steaming has received general acceptance throughout the treating industry, some purchasers of treated wood discourage the practice, especially for items which are to be used under severe conditions of exposure to termites and decay-producing organisms. The latter has been especially true with utility poles. The cautious approach with utility poles has been based on the belief that final steaming, or other after-treatment conditioning methods, removes preservative only from the outer shell of the treated wood, and to a point below the safe level for long life in contact with the ground. Since utility poles constitute the largest volume of wood pressure treated with pentachlorophenol-petroleum solutions, a program of investigation was started to determine the exact effect that final steaming has on the pentachlorophenol retention and distribution in this form of treated wood.

Southern yellow pine poles were selected for the investigation on the basis of availability and the thick sapwood characteristic of poles of this species. Air-seasoned rather than green poles were selected because the former are more likely to have a dirty surface following an empty-cell treatment with preservative. The program of investigation was designed to obtain initial, intermediate, and long-range effects of final steaming on the preservative gradient—namely, immediately, four months and a period of several years following treatment. This paper includes only the results obtained for the initial and intermediate objectives. The effect of prolonged exposure will be reported in another paper to be available in the near future.

Past Investigation

No data have been published which show the effect of final steaming on the pentachlorophenol gradient in southern pine poles. However, data were reported by Kelso, Behr and Hill[1] showing the effect of final steaming on the pentachlorophenol gradient in kiln-dried southern pine and Douglas-fir 2-inch by 4-inch boards. The authors also presented similar data for southern pine boards pressure treated with a coal tar creosote. The data presented indicated that final steaming did not change the preservative gradient in the species of lumber used in the tests.

Hudson[2] recently published a paper showing the effect of final steaming and vapor cleaning on the distribution of creosote in air-seasoned and green southern pine poles. The conclusion was offered that final steaming caused little change in the amount of creosote in the outer 1/8-inch zone in either the air-seasoned or the green poles.

Experimental Materials

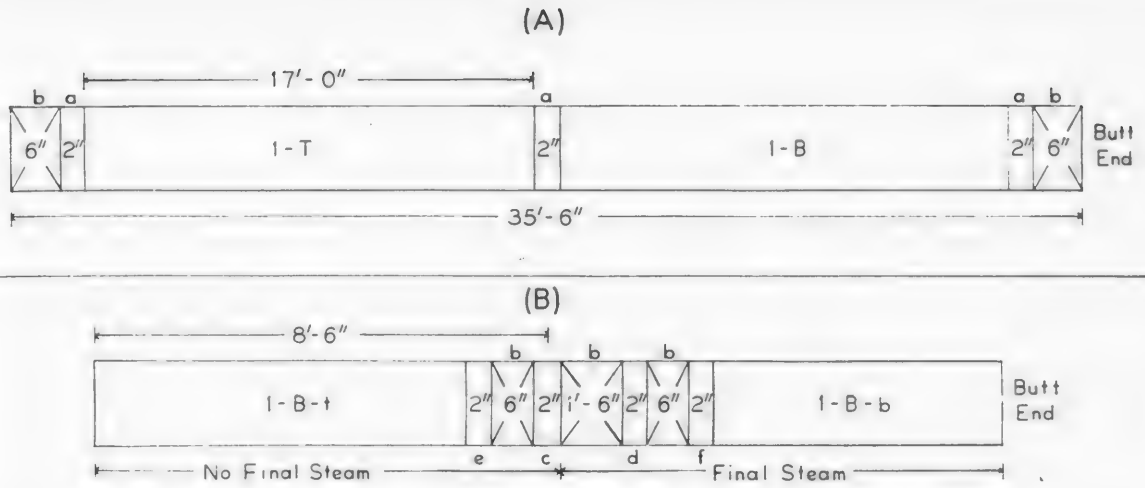
The material for treatment consisted of class 4, 35-foot machined peeled and seasoned southern yellow pine

The Authors: William C. Kelso, Jr. holds B.S.F. from Louisiana State University, M.F. from Yale. He was research forester with Miss. Agricultural Experiment Station in 1949–50, has been in charge of preservation pilot plant with Chapman Chemical Co. since 1951.

Eldon A. Behr holds B.S. and Ph.D. degrees from University of Minnesota. A member of FPRS, ACS, AWPA, TAPPI, and Sigma Xi, Dr. Behr has served on FPRS Publications Committee since 1947.

[1] Kelso, W. C., Jr., E. A. Behr, and C. E. Hill, Jr. Pentachlorophenol gradients in pressure treated wood under exposure to weather. For. Prod. Jour. V(5):369–77.

[2] Hudson, M. S. 1955. A study of creosote treatment of seasoned and green southern pine poles. I. Impregnation and distribution of creosote in southern pine poles. A.W.P.A. Preprint



a - Discs for determination of average density (oven-dry weight and green volume basis) of untreated pole sections "T" and "B".

b - Discarded.

c - Analysis disc taken immediately after treatment.

d - Analysis disc taken immediately after treatment and steaming.

e - Analysis disc taken 4 months after treatment.

f - Analysis disc taken 4 months after treatment and steaming.

Fig. 1.—Method of cutting poles for treatment (A) and analysis (B). Pole No. 1 and Pole Section No. 1-B illustrated.

Table 2.—STEAMING SCHEDULES AND WOOD WEIGHTS BEFORE AND AFTER STEAMING AIR-SEASONED SOUTHERN PINE POLE SECTIONS FOLLOWING PRESSURE TREATMENT WITH PENTACHLOROPHENOL-PETROLEUM

Charge No. (1)	Pole and Section No.* (2)	Final Steam Bath: Maximum Steam Temperature (°F.) (3)	Final Steam Bath: Time to Maximum Temperature (minutes) (4)	Final Steam Bath: Time at Maximum Temperature (minutes) (5)	Vacuum After Steaming: Time to Maximum Vacuum (minutes) (6)	Vacuum After Steaming: Time at Maximum Vacuum (minutes) (7)	Vacuum After Steaming: Maximum Vacuum (in. Hg.) (8)	Wood Weight† (lb./cu. ft.): Before Steaming (9)	Wood Weight† (lb./cu. ft.): After Steaming (10)	Weight Loss During Steam and Vacuum Cycle‡ (lb./cu. ft.) (11)
299	1-B-b	259	60	120	15	45	25.5	43.05	41.54	1.51
300	2-B-b	259	60	120	15	45	27.5	46.47	43.51	2.96
301	2-B-t	259	60	120	15	45	27.5	48.03	45.61	2.42
302	3-T-b	259	60	120	15	45	28.0	48.64	42.12	6.52
303	3-B-b	259	60	180	15	45	26.5	46.85	42.54	4.31
304	4-B-b	259	60	180	15	45	25.6	48.27	46.23	2.04

*Number preceding "B" or "T" is pole number. Letters following "B" or "T" refer to top (t) or bottom (b) one-half of section "B" or "T" which was steamed following impregnation with preservative. For example, "1-B-b" indicates that the bottom one-half of section "B" from pole No. 1 was steamed following treatment.
†Based on weights and measurements of sections before and after steaming.
‡Calculated from Columns 9 and 10.

Table 3.—DISTRIBUTION OF PENTACHLOROPHENOL AND SOLVENT IN AIR-SEASONED SOUTHERN PINE POLE SECTIONS IMMEDIATELY AFTER PRESSURE TREATMENT AND IMMEDIATELY AFTER FRESSURE TREATMENT AND STEAMING *

Charge No. (1)	When Analyzed (2)	Distribution of Pentachlorophenol in Cross-Section (lb./cu. ft.): First ¼-inch (3)	Second ¼-inch (4)	Second ½-inch (5)	Second 1-inch (6)	Third 1-inch (7)	Core (8)	Weighted Average (9)	Distribution of Solvent in Cross-Section (lb./cu. ft.): First ¼-inch (10)	Second ¼-inch (11)	Second ½-inch (12)	Second 1-inch (13)	Third 1-inch (14)	Core (15)	Weighted Average (16)
299	Before Steaming	0.901	0.490	0.279	0.256	0.220	0.184	0.327	18.41	10.00	5.47	4.97	4.31	4.34	6.64
	After Steaming†	0.700	0.387	0.214	0.176	0.150	0.110	0.239	14.48	7.47	3.18	2.66	2.56	2.35	4.30
300	Before Steaming	0.990	0.637	0.376	0.259	0.258	0.251	0.395	18.14	12.55	6.18	4.85	4.83	4.79	7.28
	After Steaming	0.851	0.511	0.318	0.273‡	0.253	0.192	0.353	14.72	8.47	5.33	4.91	4.46	3.42	6.10
301	Before Steaming	0.977	0.674	0.374	0.280‡	0.251	0.201	0.374	18.27	12.25	6.74	5.28	4.07	3.98	6.84
	After Steaming	0.795	0.501	0.348‡	0.244	0.201	0.169	0.314	13.75	8.72	5.39	4.25	3.89	2.38	5.32
302	Before Steaming	0.990	0.548	0.422	0.271	0.194	0.191	0.386	17.64	9.04	7.48	4.12	2.34	2.55	6.27
	After Steaming	0.720	0.455	0.385‡	0.226	0.163	0.164	0.317	12.16	7.93	6.55	3.77	2.05	2.17	5.15
303	Before Steaming	0.951	0.544	0.347	0.262	0.154	0.152	0.335	18.01	9.67	6.05	4.00	1.48	1.90	5.48
	After Steaming	0.755	0.430	0.289	0.206	0.133	0.128	0.270	14.21	6.86	3.72	2.15	1.11	1.81	3.80
304	Before Steaming	1.191	0.796	0.456	0.348	0.261	0.177‡	0.444	22.08	14.84	8.40	6.19	4.11	3.23	8.01
	After Steaming	0.868	0.629	0.367	0.261	0.205	0.173‡	0.345	16.78	12.08	6.36	4.15	3.05	3.36	6.12
Average	Before Steaming	1.000	0.615	0.376	0.279	0.223	0.193	0.377	18.76	11.40	6.72	4.90	3.53	3.47	6.75
	After Steaming	0.782	0.486	0.320	0.231	0.184	0.156	0.306	14.35	8.58	5.09	3.65	2.86	2.58	5.13
Average removed by steaming, %		21.80	20.98	14.89	17.20	17.49	19.17	18.83	23.51	24.74	24.26	25.51	18.98	25.65	24.00

*The treating solution consisted of 4.96% pentachlorophenol in a solvent mixture composed of 90% Aromatic HB oil and 10% 101E oil on a weight basis.
The final steam bath consisted of raising the steam temperature to 259°F. in 1 hour and maintaining it at this level for 2 hours except that with chgs. No. 303 and 304 the steam temperature was maintained at 259°F. for 3 hours. A 1-hour final vacuum followed the steaming period.
‡Recheck values.

Table 1.—TREATING SCHEDULES AND RESULTS OF TREATMENTS FOR AIR-SEASONED SOUTHERN PINE POLE SECTIONS *

Charge No. (1)	Pole No. (2)	Section No.** (3)	Total Volume (cu. ft.) (4)	Wood Weight† (lb./cu. ft.) Before Treatment (5)	Wood Weight† (lb./cu. ft.) After Treatment (6)	Avg. Oven-dry Wood Weight‡ (lb. cu. ft.) (7)	Avg. Moisture Content before Treatment§ (percent) (8)	Initial Air Pressure‖ (psi) (9)	Maximum Preservative Pressure (psi) (10)	Time to Maximum Pressure (minutes) (11)	Time at Maximum Pressure (minutes) (12)	Average Preservative Temperature °F. (13)	Vacuum After Impregnation: Time to Maximum Vacuum (minutes) (14)	Vacuum After Impregnation: Time at Maximum Vacuum (minutes) (15)	Vacuum After Impregnation: Maximum Vacuum (in. Hg.) (16)	Net Retention¶ (lb./cu. ft.): Ruping Tank (17)	Net Retention¶ (lb./cu. ft.): Section Weights (18)
299	1	B	10.31	33.32	40.35	30.44	9.46	30	150	30	30	155	15	15	27.2	6.37	7.03
300	2	T	8.14	36.92	46.07	30.02	22.98	25	150	30	30	157	15	15	26.6	7.34	9.15
301	2	B	12.04	37.56	45.43	33.44	12.98	25	150	30	30	156	15	15	26.9	7.30	7.85
302	3	T	6.40	36.16	48.99	29.02	24.60	20	150	30	30	155	15	15	28.9	14.28	12.83
303	3	B	10.11	36.15	45.10	31.91	13.29	25	150	30	20	158	15	15	28.1	8.06	8.95
304	4	B	12.47	34.60	43.14	29.49	17.37	20	150	30	9	154	15	15	25.0	8.30	8.54

*The treating solution consisted of 4.96% pentachlorophenol in a solvent mixture composed of 90% Aromatic HB Oil and 10% 101E on a weight basis.
†Based on air-dry volume and section weights before and after treatment.
‡Based on average oven-dry weight and green volume of discs cut from each end of each pole section immediately prior to treatment.
§Calculated from data given in Columns 5 and 7.
‖Initial air pressure held 1 minute before preservative line to cylinder opened.
¶Retention given is that before steaming after treatment. Retention based on section weights is more reliable than that obtained from ruping tank measurements.
**"T"—top one-half of 35-foot pole; "B"—Bottom one-half of 35-foot pole.

poles. A total of four poles were used in the tests. The average moisture content of the poles before treatment ranged from 9.5 to 24.6 per cent, while the average value for all of the poles was 16.7 per cent. All poles contained at least 4 inches of sapwood. The maximum depth of heartwood for an individual pole was 0.6 inch.

A mixture of two petroleum solvents was used in preparing the treating solution. The solvent mixture was composed of 90 per cent of an aromatic gas oil called "Aromatic HB"[3] and 10 per cent of a heavy gas oil.[4] Prior to treatment of the first charge, 5.1 per cent by weight of technical pentachlorophenol was added to the solvent mixture. Typical characteristics of the petroleum solvents are given in Appendix 1.

Experimental Methods

(a) Preparation of Material for Treatment: The poles were cut in half for treatment. The average density of each section for treatment was determined from discs taken from the untreated poles. The method of cutting the poles for treatment is illustrated in Fig. 1A.

The discs for the density determinations were dried in an oven and weighed before soaking in water for 48 hours. The green volume of each disc was determined by the water-immersion method. These values were used to calculate the oven-dry density of each disc. The values obtained for the discs were averaged to determine the oven-dry density of each pole and pole section.

Each pole section for treatment was 17 feet in length. The top and butt sections from the poles were identified by the letters "T" and "B" respectively. Weights and measurements obtained from each section immediately before treatment were used to calculate the volume and average weight per cubic foot at the time of treatment. The average moisture content at the time of treatment was calculated on the basis of the difference between the former weight per cubic foot and the weight per cubic foot found from the density when oven dry.

(b) Treatment of Material: Each charge for treatment consisted of a single pole section. Preservative impregnation was accomplished by using an empty-cell schedule. The desired net retention before final steaming was 10.0 lb./cu. ft. The net retention before steaming was determined from the weight gained during treatment. Data obtained during the treatment of each charge are given in Table 1. Because of low retention and excessive knots, two of the sections were discarded, and results for only six sections are given in Table 1. The sections discarded were the top sections from poles No. 1 and 4.

Immediately following treatment, a disc 2 inches long along the grain was removed from the center of each pole section to be extracted and analyzed by zones for pentachlorophenol and solvent distribution before steaming. The two pieces remaining after cutting the analysis disc were weighed and measured and one was stored on skid poles and the other was returned to the cylinder and given a final steam bath. A neoprene gasket was placed over the fresh-cut end of the piece to be steamed to prohibit direct contact of steam with this end. The pieces given a final steam bath, with one exception, were the butt pieces of the pole sections. Data obtained during the steaming of each charge are given in Table 2.

The pentachlorophenol and solvent distribution immediately after steaming was determined by extracting a 2-inch disc taken 18 inches from the end containing the neoprene gasket.

The pieces remaining from the steamed and non-steamed sections after cutting the original extraction discs were stored on treated skid poles for four months before additional discs were cut from 8 of the 12 pieces. These discs were extracted to determine if final steaming had any effect on the distribution and permanence of the preservative within the first four months after treatment. The method of securing the extraction discs from the pole sections immediately and four months after treatment only and treatment and steaming is illustrated in Fig. 1B.

The pieces remaining after cutting the extraction discs following storage on skid poles were installed in the ground for further weathering. Following several years' exposure, additional discs will be extracted in accordance with the long-range objectives of the project. The results of this phase of the project will be reported in a future paper.

(c) Analysis of Discs for Pentachlorophenol and Solvent Distribution: The extraction and analysis of all discs was identical. Each disc was marked and split into the following zones for extraction: outer ¼-inch; second ¼-inch; second ½-inch; second 1-inch; third 1-inch; and remainder or core. After separation into zones, a piece ½-inch long along the grain was removed from each end of each

[3] Produced by Enjay Company, Baton Rouge, La.

[4] Produced by Pan Am Southern Corp., El Dorado, Ark., and sold to wood treating industry as 101E.

zone and discarded to eliminate the possibility of any error being introduced by solution spreading over the end grain between the time of cutting the discs and separation into zones for extraction.

The remaining portion of each zone (1 inch along the grain) was chipped into small pieces, weighed, and placed in a soxhlet extractor for extraction with toluene. The water was collected in a trap at the top of the soxhlet and measured, and extraction was continued for a minimum of 7 hours after removal of the water. The extract was concentrated and analyzed for pentachlorophenol by the lime ignition method. The extracted chips were dried in an oven and weighed. A 4-gram sample of the oven-dried chips from each zone was analyzed for residual pentachlorophenol by the lime ignition method. Any pentachlorophenol found in the extracted chips was added to that found by analysis in the extract. The total solution content in each zone was determined from the weight lost during extraction after correction for the water collected in the trap. The actual retention of solvent was determined by subtracting the pentachlorophenol retention from the solution retention.

The pentachlorophenol and solvent retention was expressed in pounds per cubic foot based on the actual oven-dry density of the extracted chips from each zone. The density of the extracted chips was determined based on green volume and oven-dry weight. The green volume was determined by the water immersion method after the extracted and oven-dried chips had been given a full-cell treatment with water so that all of the chips were heavier than water. The weighted average retention for each disc was determined based on the area that each zone occupied in relation to the total cross-sectional area. The values used to obtain the weighted average retention for each disc are contained in Appendix 2.

Experimental Results

Data obtained for the discs extracted immediately after treatment and immediately after treatment and steaming are presented in Table 3. Some of the values given for pentachlorophenol retention in this table are recheck values. The zones rechecked for pentachlorophenol retention are identified by reference to a footnote at the bottom of

Table 4.—DISTRIBUTION OF PENTACHLOROPHENOL AND SOLVENT IN AIR-SEASONED SOUTHERN PINE POLE SECTIONS IMMEDIATELY AFTER TREATMENT AND AFTER EXPOSURE FOR FOUR MONTHS

Charge No.	When Analyzed After Treatment	Distribution of Pentachlorophenol in Cross-Section (lb./cu. ft.)							Distribution of Solvent in Cross-Section (lb./cu. ft.)						
		First ¼-inch	Second ¼-inch	Second ½-inch	Second 1-inch	Third 1-inch	Core	Weighted Average	First ¼-inch	Second ¼-inch	Second ½-inch	Second 1-inch	Third 1-inch	Core	Weighted Average
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
						NO FINAL STEAMING									
299	Immediately	0.901	0.490	0.279	0.256	0.220	0.184	0.327	18.41	10.00	5.47	4.97	4.31	4.34	6.64
	4 months	1.161	0.458	0.259	0.243	0.212	0.183	0.342	16.98	5.58	2.87	3.17	3.06	3.50	4.75
		*1.110						*0.337	*14.51						*4.50
300	Immediately	0.990	0.637	0.376	0.259	0.258	0.251	0.395	18.14	12.55	6.18	4.85	4.83	4.79	7.28
	4 months	1.231	0.487	0.290	0.240	0.232	0.212	0.374	18.48	7.04	3.96	2.31	1.92	2.65	4.77
		*1.107						*0.361	*15.53						*4.45
301	Immediately	0.977	0.674	0.374	0.280	0.251	0.201	0.374	18.27	12.25	6.74	5.28	4.07	3.98	6.84
	4 months	1.140	0.612	0.332	0.281	0.226	0.209	0.373	16.45	10.17	3.84	3.33	2.05	2.27	4.75
		*1.090						*0.368	*16.31						*4.73
302	Immediately	0.990	0.548	0.422	0.271	0.194	0.191	0.386	17.64	9.04	7.48	4.12	2.34	2.55	6.27
	4 months	1.090	0.466	0.365	0.259	0.216	0.170	0.374	16.83	6.27	4.22	2.82	2.22	2.50	4.83
		*1.009						*0.363	*15.71						*4.71
Average:	Immediately	0.965	0.587	0.363	0.267	0.231	0.207	0.371	18.12	10.96	6.47	4.81	3.89	3.92	6.76
	4 months	1.156	0.506	0.312	0.256	0.222	0.194	0.366	17.19	7.27	3.72	2.91	2.31	2.73	4.78
		*1.079						*0.357	*15.52						*4.60
Loss 4 Months, %		—19.8	13.8	14.0	4.1	3.9	6.3	1.3	5.1	33.7	42.5	39.5	40.6	30.4	29.3
		*—11.8						*3.8	*14.4						*32.0

*Retention not including any residual surface deposits which could be scraped off with a dull knife prior to extraction.

Table 5.—DISTRIBUTION OF PENTACHLOROPHENOL AND SOLVENT IN AIR-SEASONED SOUTHERN PINE POLE SECTIONS IMMEDIATELY AFTER TREATMENT AND STEAMING AND AFTER EXPOSURE FOR FOUR MONTHS

Charge No.	When Analyzed After Treatment	Distribution of Pentachlorophenol in Cross-Section (lb./cu. ft.)							Distribution of Solvent in Cross-Section (lb./cu. ft.)						
		First ¼-inch	Second ¼-inch	Second ½-inch	Second 1-inch	Third 1-inch	Core	Weighted Average	First ¼-inch	Second ¼-inch	Second ½-inch	Second 1-inch	Third 1-inch	Core	Weighted Average
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
						FINAL STEAM BATH									
299	Immediately	0.700	0.387	0.214	0.176	0.150	0.110	0.239	14.48	7.47	3.18	2.66	2.56	2.39	4.30
	4 months	0.817	0.350	0.197	0.171	0.156	0.134	0.244	12.20	5.26	1.51	.92	.80	1.39	2.56
		*0.764						*0.239	*11.07						*2.45
300	Immediately	0.851	0.511	0.318	0.273	0.253	0.192	0.353	14.72	8.47	5.33	4.91	4.46	3.42	6.10
	4 months	0.901	0.404	0.267	0.232	0.194	0.164	0.308	11.83	5.04	2.16	2.51	2.75	2.42	3.71
		*,†0.0						*,†0.308	*,††11.83						*,†3.71
301	Immediately	0.795	0.501	0.348	0.244	0.201	0.169	0.314	13.75	8.72	5.39	4.25	3.89	2.38	5.32
	4 months	0.996	0.441	0.281	0.224	0.186	0.176	0.308	13.63	6.70	2.91	2.25	1.76	1.94	3.65
		*0.063						*0.304	*13.16						*3.61
302	Immediately	0.720	0.455	0.385	0.226	0.163	0.164	0.317	12.16	7.93	6.55	3.77	2.05	2.17	5.15
	4 months	0.848	0.334	0.297	0.205	0.161	0.152	0.290	12.98	4.93	4.08	2.93	1.26	0.54	3.85
		*,†0.0						*,†0.290	*,†12.98						*,†3.85
Average:	Immediately	0.765	0.464	0.316	0.230	0.192	0.159	0.306	13.78	8.15	5.11	3.90	3.24	2.59	5.22
	4 months	0.891	0.382	0.261	0.208	0.174	0.157	0.288	12.66	5.48	2.67	2.15	1.64	1.57	3.44
		*0.869						*0.285	*12.26						*3.41
Loss 4 Months, %		—16.5	17.7	17.4	9.6	9.4	1.3	5.9	8.1	32.8	47.7	44.9	49.4	39.4	34.1
		*—13.6						*6.9	*11.1						*34.7

†Retention not including any residual surface deposits which could be scraped off with a dull knife prior to extraction.
††No residual surface deposits were present on these discs and surface retention was assumed to be zero.

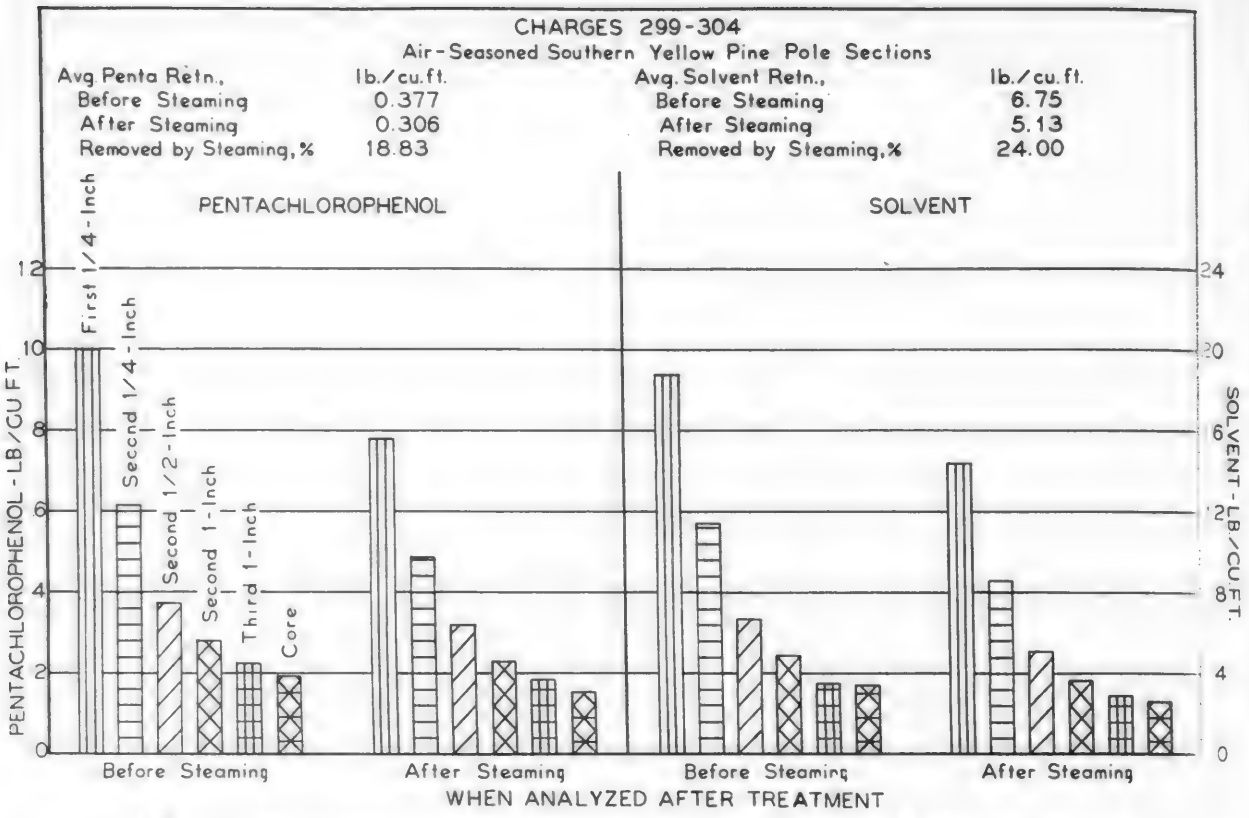


Fig. 2.—Distribution of pentachlorophenol and solvent in freshly treated southern pine pole sections immediately before and after application of a final steam bath.

the table. The zones rechecked were those that indicated little or no reduction in retention by steaming. In all cases the retention calculated from the second analysis was practically identical to that determined from the original analysis.

The distribution of pentachlorophenol and solvent in the discs extracted immediately and four months after treatment is shown in Tables 4 and 5. The results for the non-steamed discs are contained in the former table and similar data for the discs steamed after treatment are given in Table 5. Reference to these tables will indicate that two analyses were made on the first ¼-inch zone of some of the discs analyzed four months after treatment. The former was true for all of the non-steamed discs and half of the steamed discs.

The two separate extractions and analyses were made on material obtained from adjacent discs. A dull knife was used to scrape the surface of one sample and the other was not scraped. The purpose of this procedure was to determine how much pentachlorophenol was present in surface deposits present on some of the poles following weathering in a horizontal position for four months after treatment. The steamed discs not analyzed in the foregoing manner did not contain any surface deposits near the area sampled at the end of 4 months' weathering.

Discussion of Results

(a) Effect of Final Steaming on Initial Preservative Retention: The effect of final steaming on the preservative retention at different depths from the surface of the poles may be seen by a comparison of the data given in Table 3 for the discs extracted immediately before and after steaming. The average values for all the discs extracted are shown near the bottom of this table. A study of the average data in columns 3 through 9 indicates that the discs extracted immediately after treatment and steaming contained an average of 18.8 per cent less pentachlorophenol than those extracted before steaming. With the exception of the second ½-inch zone, the reduction by steaming was practically uniform throughout the cross-section. The latter zone indicated only 14.9 per cent less pentachlorophenol after steaming in comparison to 17.2 to 21.8 per cent for the other zones. The values given for individual charges offer no significant reason for the smaller reduction by steaming in the second ½-inch zone. The extracts from the charges showing the least reduction in this zone were rechecked and the results were comparable with the original values. As will be shown later, this difference did not have any significant effect on the pentachlorophenol gradient.

The data in columns 10 through 16 of Table 3 for solvent retention in the steamed and non-steamed discs offer verification for the results obtained for pentachlorophenol retention. The average reduction in solvent content was 24.0 per cent while the same value for pentachlorophenol was 18.8 per cent. The solvent removed from individual zones was more uniform than was the case with pentachlorophenol.

The slightly greater and more uniform removal of solvent is believed to be related to the effect of steaming after treatment on the solubility of pentachlorophenol and to the fact that steam distillation during the vacuum after steaming removes a higher percentage of solvent from the wood than pentachlorophenol. It has been demonstrated that steaming after treatment renders a portion of the pentachlorophenol non-extractable with a solvent such as toluene[5]. The amount non-extractable is not constant and may be expected to vary between 5 and 15 per cent of the total amount present before extraction. No evidence has been found, however, that steaming

[5] See footnote 1.

has a similar effect on the extractability of the petroleum solvent with toluene. Since thermal expansion of air and preservative in the wood is the primary force which removes preservative during the steaming period, the effect of the foregoing factors would be greater and more uniform removal of solvent than pentachlorophenol.

(b) Effect of Final Steaming on Initial Preservative Gradient: A visual impression of the pentachlorophenol and solvent gradients in the non-steamed and steamed discs may be obtained by reference to Fig. 2. The graphs in this figure were prepared by using the average values given near the bottom of Table 3. Although this figure indicates that final steaming did not change the shape of either the average pentachlorophenol or solvent gradient, it does not offer conclusive evidence that the effect was similar for individual poles. A statistical comparison of the data in Table 3 would offer a means of judging differences between the groups except for the fact that such a comparison may suggest erroneous conclusions traceable to a difference in retention between the groups rather than a difference in gradient resulting from final steaming. In order to avoid the variability introduced by any difference in cross-sectional retention between the groups, it is convenient to express the pentachlorophenol retention in each zone as per cent of the weighted average value for the whole disc. The calculation is made by multiplying the pentachlorophenol retention of each zone as given in Table 3 by the appropriate value shown in Appendix 2 and expressing the product as per cent of the weighted average retention in the disc. Any difference in the percentage values for similar zones of the group, therefore, represents a difference in distribution of the preservative. Results for calculations made by the foregoing procedure are presented in Table 6.

A statistical comparison of the data in Table 6 by the difference-between-pairs method[6] is shown in Table 7. The statistical results in this table indicate no significant difference in the two groups at the 95 per cent confidence level. It is also informative to mention that a similar conclusion was advanced by Stasse[7] concerning the effect of final steaming on the amount of preservative in the outer ⅛-inch zone of air-seasoned southern pine poles pressure treated with creosote.

The fact that experimental evidence has been found that final steaming does not change the pentachlorophenol gradient in air-seasoned pine poles should be of some value to the wood preserving industry. Its importance is magnified as a result of past beliefs that steaming reduces the concentration of preservative at the surface only, and to a point below the safe level. But the experimental data described here offer some assurance that final steaming does not significantly change the preservative gradient. In other words, if final steaming removes two pounds of solution per cubic foot from poles containing ten pounds per cubic foot, the remaining eight pounds has essentially the same distribution as if the retention had been eight pounds without final steaming.

(c) Effect of Final Steaming on Permanence and Distribution of Preservative During Storage After Treatment: As previously mentioned, the pole sections remaining after cutting the original extraction discs were stored on treated skid poles for four months following treatment before additional discs were cut for extraction. The method of sectioning the poles to obtain the latter discs is illustrated in Fig. 1B. The extractions after storage were undertaken to determine if final steaming had any effect on the permanence and distribution of the preservative during the first four months after treatment.

Table 6.—PENTACHLOROPHENOL RETENTION BY ZONES IN NON-STEAMED AND STEAMED SOUTHERN PINE POLE SECTIONS EXPRESSED AS PER CENT OF TOTAL CROSS-SECTIONAL RETENTION IMMEDIATELY AFTER TREATMENT

Charge No.	Per cent of Total Cross-Sectional Retention: First ¼-inch	Second ¼-inch	Second ½-inch	Second 1-inch	Third 1-inch	Core	Total
NON-STEAMED SECTIONS							
299	27.44	14.02	14.63	21.95	13.41	8.55	100.00
300	26.58	16.20	17.47	19.24	12.91	7.60	100.00
301	24.06	15.78	16.31	20.32	13.37	10.16	100.00
302	28.50	15.03	20.73	21.24	9.84	4.66	100.00
303	28.36	15.52	17.91	22.09	9.25	6.87	100.00
304	26.13	16.44	17.34	21.85	11.71	6.53	100.00
Average	26.84	15.50	17.40	21.11	11.75	7.40	100.00
STEAMED SECTIONS							
299	28.87	15.06	15.48	20.92	12.55	7.12	100.00
300	25.50	14.45	16.43	22.66	14.16	6.80	100.00
301	23.57	14.33	18.15	21.34	12.74	9.87	100.00
302	25.24	15.14	23.03	21.45	10.09	5.05	100.00
303	27.78	15.19	18.52	21.48	10.00	7.03	100.00
304	24.06	16.52	17.97	21.16	11.88	8.41	100.00
Average	25.84	15.12	18.26	21.50	11.90	7.38	100.00

Table 7.—STATISTICAL COMPARISON OF PENTACHLOROPHENOL GRADIENTS FOUND IN NON-STEAMED AND STEAMED SECTIONS IMMEDIATELY AFTER TREATMENT *

Zone Analyzed	Average Difference Between Pairs (per cent)	Value of "t"†
First ¼-inch	1.00	1.54‡
Second ¼-inch	0.40	0.94§
Second ½-inch	0.86	1.81‡
Second 1-inch	0.39	0.58‖
Third 1-inch	0.15	0.46‖
Core	0.02	0.04‖

* Statistical analysis based on data given in Table 6.
† Value of "t" should be 2.571 or greater for significance at the 95 per cent confidence level.
‡ Probability between 0.1 and 0.2.
§ Probability between 0.3 and 0.4.
‖ Probability more than 0.5

Data obtained from the foregoing extractions are presented in Tables 4 and 5 for the non-steamed and steamed discs respectively. The results for the original extractions as given in Table 3 are also included in these tables. It will be noted that two of the sections in each group were not extracted after four months' storage. The results obtained for the first discs extracted after storage were very uniform and it was decided to leave the remaining sections for a longer period before cutting discs for extraction. The results for the latter extraction will be reported in the near future.

The average over-all loss of pentachlorophenol from the non-steamed and steamed pole sections during the first four months after treatment as shown at the bottom of Tables 4 and 5 was 1.3 and 5.9 per cent respectively. The corresponding loss of solvent was 29.3 and 34.1 per cent. The outer ¼-inch zone of both the non-steamed and steamed discs indicated an increase in pentachlorophenol during the storage period, whereas a decrease was evident in the interior zones. The greatest reduction inside the outer ¼-inch was in the second ¼-inch and second ½-inch zones. The latter was true for both the non-steamed and steamed discs. In contrast, all zones of both the non-steamed and steamed discs showed a loss of solvent during the storage period. The smallest loss of solvent was in the outer ¼-inch, but much greater losses were noted in all interior zones.

As shown in column 3 of Tables 4 and 5, the steamed sections had less residual surface deposits following four months' storage than the non-steamed sections. These surface deposits were oily and dark-colored in appearance and were caused by the surface becoming wet with preservative a few minutes after removal from the cylinder. As the storage period increased, the wet areas dried and a gummy, amorphous deposit remained on the surface of the sections. All of the non-steamed sections contained

[6] Youden, W. J. 1951. Statistical methods for chemists. John Wiley and Sons, Inc., pp. 24–29.
[7] Stasse, H. L. 1955. A study of creosote treatment of seasoned and green southern pine poles. Appendix to Part I—Statistical Analysis of Retention Data. AWPA Preprint.

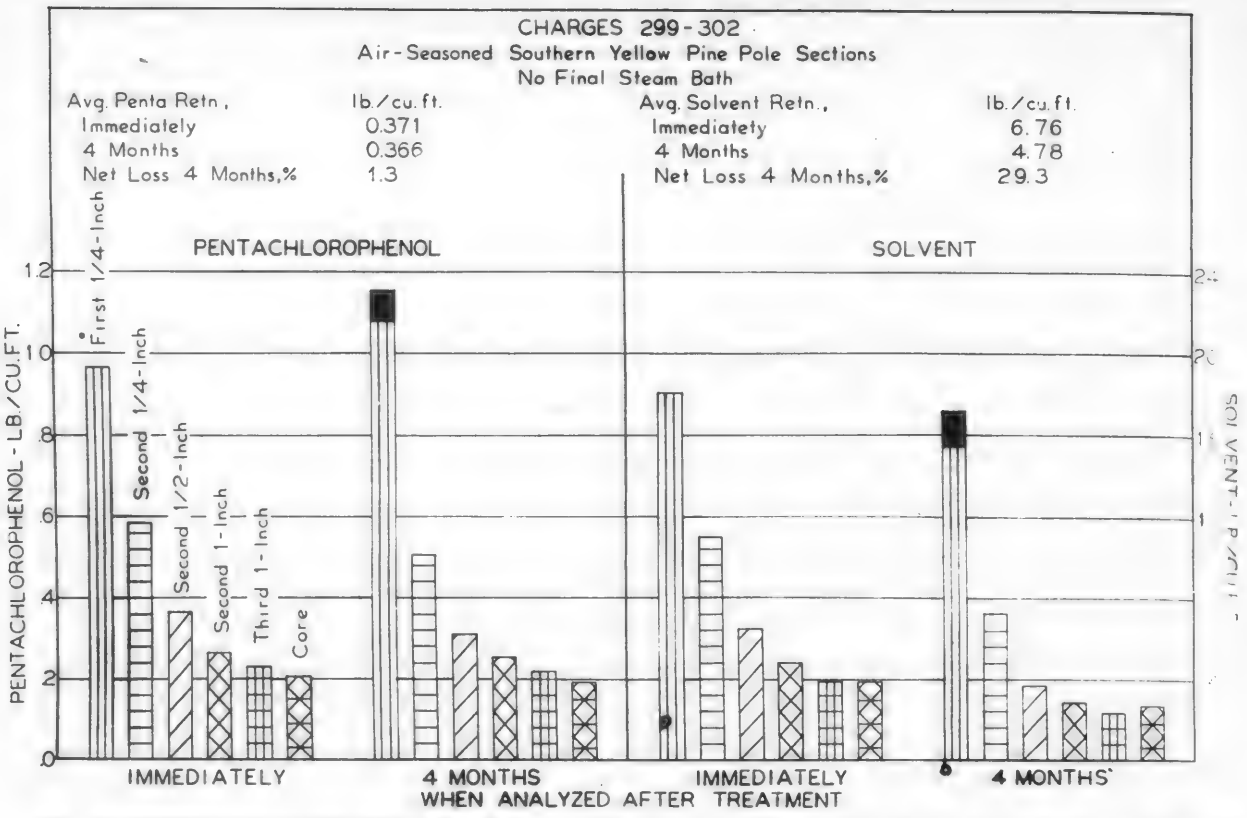


Fig. 3.—Distribution of pentachlorophenol and solvent in southern pine pole sections immediately after treatment and four months after treatment and storage. No steam was used following treatment. Shaded area of first ¼-inch zone indicates quantity of pentachlorophenol or solvent on surface of the extraction discs in the form of tar-like deposits.

large amounts of this gummy material which softened when exposed to sunlight and was sticky to the touch. Only two of the steamed sections showed any evidence of surface deposits. The few deposits found on the steamed sections were scattered in small patches and were definitely less objectionable from a handling standpoint than those found on the non-steamed sections.

In spite of the cleaner surface of the steamed sections, the average values given near the bottom of Tables 4 and 5 indicate that slightly more pentachlorophenol and solvent were lost from these sections during the storage period than from the non-steamed sections. The overall loss of pentachlorophenol and solvent from the non-steamed sections was 1.3 and 29.3 per cent respectively. Comparable values for the steamed sections were 5.9 and 34.1 per cent. The amount of pentachlorophenol lost from both groups is considered to be insignificant and within the range of experimental error. The sizeable loss of solvent is significant and worthy of further consideration.

Examination of the average values given near the bottom of Tables 4 and 5 indicates a solvent loss between 30 and 50 per cent for all zones inside the outer ¼-inch. The loss of pentachlorophenol from the same zones ranged between 1 and 18 per cent. The largest loss of solvent was in the area inside the outer 1-inch, which also represented the area showing the least change in pentachlorophenol content. The large solvent loss in this area with little change in pentachlorophenol content suggests that either a substantial quantity of the solvent moved to the surface in the vapor phase or some pentachlorophenol was precipitated from the solution after it was impregnated into the wood. In the case of the steamed sections one might favor the latter assumption because of the effect of steaming on the extractability of pentachlorophenol with a solvent such as toluene. The effect is similar in the non-steamed sections, however, and this seems to indicate that a considerable quantity of the solvent lost from the interior of the sections moved to the surface as a vapor rather than a liquid. Kelso, Behr and Hill[8] reached a similar conclusion concerning southern pine poles treated in the green condition with pentachlorophenol-petroleum and exposed for 18 months.

The fact that it is possible to have a large loss of solvent from the interior of a pole with only a slight loss or movement of pentachlorophenol toward the wood surface should serve to reduce the importance of the so-called "migration" of pentachlorophenol-petroleum in this type of pressure-treated wood. Past reports concerning migration have tended to create the impression that practically all of the pentachlorophenol concentrates on or near the surface of the wood as the more volatile part of the solvent escapes from the wood. But the data in Tables 4 and 5 offer evidence that the former concept of migration does not necessarily apply to southern pine poles pressure treated with a pentachlorophenol-petroleum solution. Some movement of pentachlorophenol does occur but it is small in relation to the loss or movement of solvent.

The average values given in Tables 4 and 5 are presented graphically in Figs. 3 and 4 for the non-steamed and steamed sections respectively. The shaded area in the outer ¼-inch zone corresponds to the amount of pentachlorophenol or solvent on the surface of the sections four months after treatment.

A cross-comparison of the gradients in the foregoing figures suggests that the movement of pentachlorophenol and solvent in the steamed sections during the storage period was similar to that which occurred in the non-steamed sections. Expression of the pentachlorophenol values used in pre-

[8] See footnote 1.

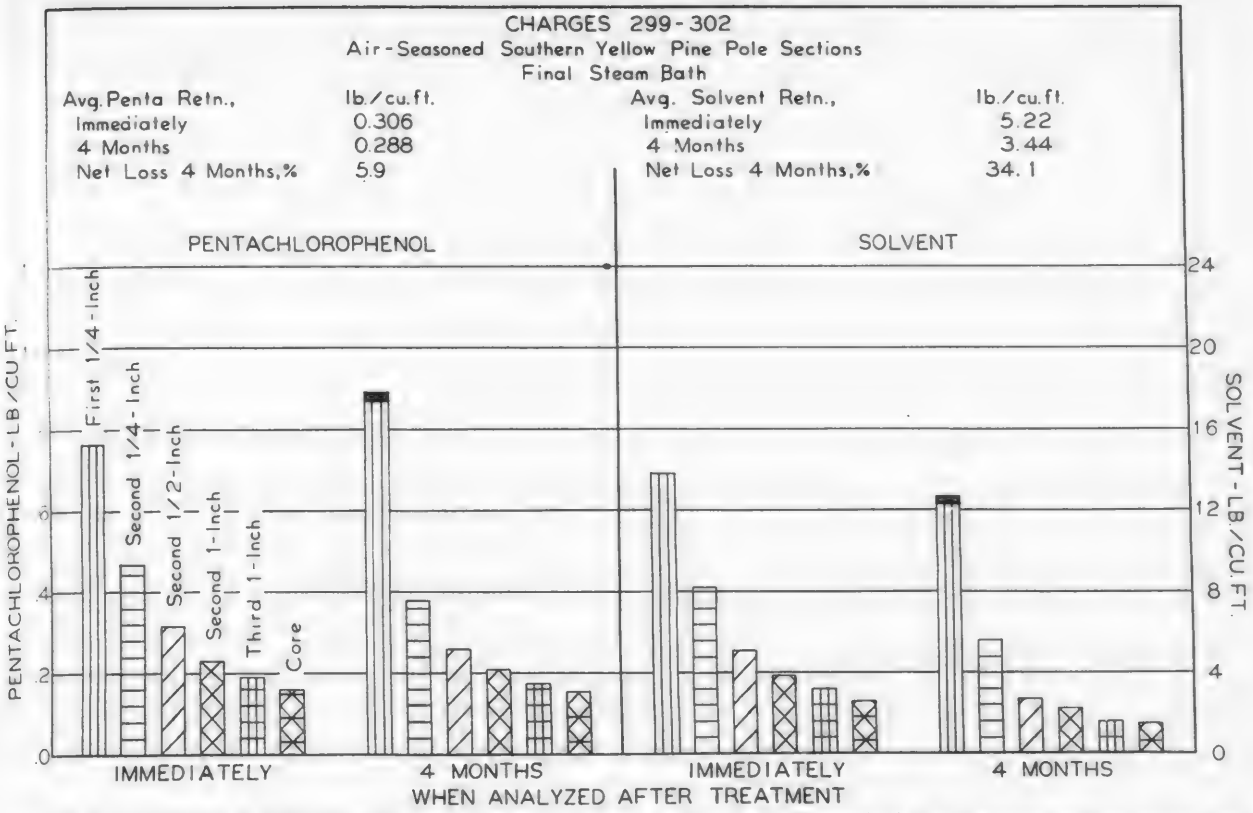


Fig. 4.—Distribution of pentachlorophenol and solvent in southern pine pole sections immediately after treatment and four months after treatment and storage. A final steam bath was employed after impregnation. Shaded area of first ¼-inch zone indicates quantity of pentachlorophenol or solvent on surface of the extraction discs in the form of tar-like deposits.

paring these figures as per cent of the total retention in each disc yields the data shown in Tables 8 and 9 for the non-steamed and steamed sections respectively.

A statistical comparison of the data given in the above tables supports the following statements concerning the pentachlorophenol gradient: 1) there was no significant difference in the pentachlorophenol gradients in the non-steamed and steamed sections either immediately or four months after treatment; 2) both the non-steamed and steamed sections had significantly more pentachlorophenol in the outer ¼-inch zone four months after treatment than was present in this same zone immediately following treatment; and 3) the non-steamed sections showed a significant decrease in the amount of pentachlorophenol in the second ¼-inch and second ½-inch zones during the storage period, whereas the steamed sections showed a significant decrease in the second ¼-inch, second ½-inch, and second 1-inch zones during the same period. The change in the remaining zones during the storage period was not significant.

Summary and Conclusions

Air-seasoned southern pine poles were pressure treated with a pentachlorophenol-petroleum solution and extracted for pentachlorophenol and solvent distribution immediately before and after steaming following treatment. Sections from the same poles were also extracted following a storage period of four months after treatment.

Table 8.—PENTACHLOROPHENOL RETENTION BY ZONES IN NON-STEAMED SOUTHERN PINE POLE SECTIONS EXPRESSED AS PER CENT OF TOTAL CROSS-SECTIONAL RETENTION IMMEDIATELY AND FOUR MONTHS AFTER TREATMENT

Charge No.	Per cent of Total Cross-Sectional Retention						
	First ¼-inch	Second ¼-inch	Second ½-inch	Second 1-inch	Third 1-inch	Core	Total
IMMEDIATELY AFTER TREATMENT							
299	27.44	14.02	14.63	21.95	13.41	8.55	100.00
300	26.58	16.20	17.47	19.24	12.91	7.60	100.00
301	24.06	15.78	16.31	20.32	13.37	10.16	100.00
302	28.50	15.03	20.73	21.24	9.84	4.66	100.00
Avg.	26.65	15.26	17.29	20.69	12.38	7.74	100.00
FOUR MONTHS AFTER TREATMENT							
299	33.92	12.57	13.16	20.18	12.28	7.89	100.00
300	34.76	13.10	14.17	18.72	12.30	6.95	100.00
301	28.15	14.21	14.48	20.38	12.06	10.72	100.00
302	32.09	12.83	18.45	20.86	11.23	4.54	100.00
Avg.	32.23	13.18	15.07	20.04	11.97	7.51	100.00

Table 9.—PENTACHLOROPHENOL RETENTION BY ZONES IN STEAMED SOUTHERN PINE POLE SECTIONS EXPRESSED AS PER CENT OF TOTAL CROSS-SECTIONAL RETENTION IMMEDIATELY AND FOUR MONTHS AFTER TREATMENT AND STEAMING

Charge No.	Per cent of Total Cross-Sectional Retention						
	First ¼-inch	Second ¼-inch	Second ½-inch	Second 1-inch	Third 1-inch	Core	Total
IMMEDIATELY AFTER TREATMENT AND STEAMING							
299	28.87	15.06	15.48	20.92	12.55	7.12	100.00
300	25.50	14.45	16.43	22.66	14.16	6.80	100.00
301	23.57	14.33	18.15	21.34	12.74	9.87	100.00
302	25.24	15.14	23.03	21.45	10.09	5.05	100.00
Avg.	25.80	14.75	18.27	21.59	12.39	7.20	100.00
FOUR MONTHS AFTER TREATMENT AND STEAMING							
299	31.97	13.11	13.52	19.67	12.70	9.03	100.00
300	30.52	12.66	15.58	21.75	12.66	6.83	100.00
301	30.19	12.66	14.94	19.81	12.01	10.39	100.00
302	31.72	11.72	18.97	21.03	11.03	5.53	100.00
Avg.	31.10	12.54	15.75	20.57	12.10	7.94	100.00

It was found that the final steaming schedule employed removed approximately 19 per cent of the pentachlorophenol present in the wood before steaming. It should be recalled, however, that this is not actually a "loss" as this preservative is removed in the cylinder and returned to the working tank. The solvent removed during the same period was slightly less than 25 per cent. The removal of both pentachlorophenol and solvent was uniform throughout the cross-section of the poles, and a statistical comparison of the data indicated that the steaming did not produce any significant difference in the preservative gradient. It is pointed out that the amount of preservative removed by final steaming may be offset by over-treatment before steaming by approximately 25 per cent more than that required after steaming.

The steamed sections were much cleaner on the surface both immediately and four months after treatment than the non-steamed sections. Bleeding which started soon after removal from the cylinder was responsible for the objectionable surface condition of the non-steamed sections.

The analyses following a storage period of four months showed that the steamed sections lost slightly more pentachlorophenol and solvent than the non-steamed sections. The overall loss of pentachlorophenol and solvent from the non-steamed sections was 1.3 and 29.3 per cent respectively. Comparable values found for the steamed sections were 5.9 and 34.1 per cent respectively. The loss of pentachlorophenol from both groups was considered insignificant and within the range of experimental error. The loss of solvent from both groups was significant.

Solvent losses during the storage period were much higher in the area inside the outer 1-inch zone than pentachlorophenol losses in the same area. This suggests that a large quantity of the solvent lost during the storage period moved to the surface in the vapor phase while the majority of the pentachlorophenol remained stationary. A large loss of solvent from the interior of a pole, therefore, is not necessarily indicative of similar movement or loss of the pentachlorophenol.

A statistical comparison of the pentachlorophenol gradients immediately and four months after treatment indicated that both the non-steamed and steamed poles contained significantly more pentachlorophenol in the outer ¼-inch zone and less in the second ¼-inch and second ½-inch zones after the storage period than was present in the same zones before storage. In addition, the steamed poles showed a significant decrease in the pentachlorophenol content in the second 1-inch zone during the storage period. The changes in the other zones during the storage period were not significant by the statistical procedure employed.

Appendix 1.—CHARACTERISTICS OF PETROLEUM SOLVENTS USED WITH PENTACHLOROPHENOL TREATMENTS

Petroleum Oil	(1) Aromatic HB	(2) 101E	(3) 90–10 mixture of (1) and (2)
API Gravity at 60° F.	18.8	4.8	14.4*
Viscosity at 100° F., SUS	37.8	107	
Pentachlorophenol Solvency at 75° F., %	15	24	16
Distillation Range, °F.:			
IBP	425	430	400*
10%	488	580	490
50%	530	671	537
90%	569	753	636
FBP	610	762	652

*Sample contained 4.96 per cent pentachlorophenol at time of analysis.

Appendix 2.—VALUES USED IN DETERMINING WEIGHTED AVERAGE PENTACHLOROPHENOL AND SOLVENT CONTENT OF EXTRACTION DISCS TAKEN FROM AIR-SEASONED SOUTHERN PINE POLE SECTIONS

Charge No. (1)	Disc No.* (2)	Diameter of Disc (inches) (3)	Depth of Sapwood (inches) (4)	Depth of Heartwood (inches) (5)	Percent of Total Cross-Sectional Area in Each Individual Zone: First ¼-inch (6)	Second ¼-inch (7)	Second ½-inch (8)	Second 1-inch (9)	Third 1-inch (10)	Core (11)	Total (12)
299	1	9.79	4.27	0.63	9.96	9.41	17.29	28.32	19.99	15.03	100.00
	2	9.88	4.31	0.63	9.84	9.39	17.17	28.20	20.00	15.40	100.00
	3	9.78	4.33	0.56	9.96	9.45	17.32	28.35	19.98	14.94	100.00
	4	10.12	4.44	0.62	9.60	9.19	16.84	27.80	20.01	16.56	100.00
300	1	9.13	4.32	0.25	10.64	10.06	18.29	29.41	19.82	11.78	100.00
	2	9.25	4.38	0.25	10.54	9.89	18.10	29.20	19.86	12.41	100.00
	3	9.19	4.35	0.25	10.59	9.97	18.19	29.30	19.86	12.09	100.00
	4	9.38	4.32	0.37	10.42	9.77	17.91	28.99	19.92	12.99	100.00
301	1	10.57	4.79	0.50	9.22	8.79	16.22	27.10	19.94	18.73	100.00
	2	10.44	4.72	0.50	9.36	8.89	16.40	27.30	19.96	18.09	100.00
	3	10.63	4.94	0.37	9.19	8.73	16.15	26.99	19.93	19.01	100.00
	4	10.50	4.88	0.37	9.29	8.86	16.32	27.21	19.96	18.36	100.00
302	1	8.69	4.10	0.25	11.15	10.51	19.03	30.13	19.55	9.63	100.00
	2	8.75	4.13	0.25	11.05	10.49	18.92	30.04	19.60	9.90	100.00
	3	8.82	4.10	0.31	11.00	10.38	18.82	29.93	19.64	10.23	100.00
	4	8.94	4.10	0.37	10.87	10.26	18.62	29.73	19.71	10.81	100.00
303	1	9.75	4.50	0.38	9.95	9.49	17.35	28.40	19.99	14.82	100.00
	2	9.82	4.54	0.38	9.90	9.43	17.24	28.29	19.99	15.15	100.00
304	1	10.76	5.02	0.37	9.73	9.21	16.94	27.94	19.99	16.19	100.00
	2	11.13	5.07	0.50	9.61	9.14	16.82	27.78	19.99	16.66	100.00
Average:		9.77	4.48	0.41	10.09	9.57	17.50	28.52	19.88	14.44	100.00

*Disc No. 1—cut immediately after treatment; Disc No. 2—cut immediately after treatment and steaming; Disc No. 3—cut four months after treatment; Disc No. 4—cut four months after treatment and steaming.

Flexible Paper- and Fabric-Backed Veneers[1]

JAMES J. DUNNE
Vice-President, U. S. Plywood Corp., New York, N. Y.

Factors involved in the development of flexible wood veneers, including cutting requirements and other specifications, are discussed. Steps in the manufacturing process are outlined and installation methods described. Illustrations are presented of various applications of flexible wood veneers.

IT IS A GENERALLY ACCEPTED fact that the Egyptians first made use of veneers and found means of gluing them to supporting surfaces. Now credit must be given to the twentieth century for developing flexible wood veneers.

The term wood veneering in a commercial sense got its origin a good many years ago. The term veneer apparently first came into common usage, insofar as wood is concerned, when the veneer chair seat was developed. The comfort of the sitter was helped, it was believed, by drilling holes in the seat. The plywood chair seat and back was originated by a man named Gardner in about 1875.

Looking back on the development of the veneer and plywood industry, it is interesting to note that many of the original "veneer and seating companies" all became plywood manufacturers and incorporated the words "veneer" and "seating" into the company name. For example, Frost Veneer and Seating Company.

[1] Presented at meeting of FPRS Northeast Section, April 19–20, 1956, in Springfield, Mass.

The Author: J. J. Dunne has been associated with U. S. Plywood Corp. since 1931. He was named a director in 1938 and vice-president in 1941. Mr. Dunne worked in an aircraft plywood manufacturing plant during World War I and has since been closely identified with the technical progress of the plywood industry and concerned with all phases of marketing. He has been director of public relations for U. S. Plywood Corp. since 1952.

Development of Flexible Veneer

It wasn't until Armin Elmendorf came up with the idea of Flexwood that a truly flexible veneer came into commercial use. To make a practicable flexible veneer, the wood had to have a backing. Obviously the backing or support had to be pliable and Elmendorf explored two possibilities for backing materials—paper and fabric.

All veneers that are subsequently to be made flexible by mechanical treatment are cut rather thin, the average thickness being about 1/85 inch. Certain cuts of oak, for example, might be as heavy as 1/65 inch and a wood like Macassar ebony, for best results, might be cut to a thickness of 1/100 inch. The whole technique of veneer cutting is the same as always used. The veneers can be flat or quarter sliced or cut rotary or half round. The flitch goes through the same hot water bath as used in the development of veneers for commercial plywood or furniture use.

To those who relish the natural beauty of wood—its color, figure, and grain pattern—nature's contrariness in refusing to produce any two square feet of lumber or veneer in an identical pattern or character is a blessing. We can look at a fine Adam or Duncan Phyfe piece in mahogany or a gorgeous room interior in walnut and appreciate its unique individuality.

Those who have worked with fine decorative veneers realize how a lay person is mystified that something in veneer form can finally become the beautifully figured and polished piece of wood that is seen in the finest examples of modern veneer and plywood technology.

Complicating Factors

Until flexible veneer came into use, a split or cockle or buckle in veneer was a matter of slight consequence. In laminating a decorative veneer in plywood manufacture, the cockles or fullnesses in the veneer disappear under the application of pressure or pressure and heat and the holding quality of the adhesive used.

If a 1/85-inch veneer is cut from a flitch that is cockley by nature and a pliable backing of fabric is attached to the veneer, a horrible looking washboard is the result. The fabric backing, or paper for that matter, cannot restrain the buckling tendency of the natural wood veneer. The bumps which appear cannot be mechanically or chemically eradicated and a smooth flat film of pliable veneer is impossible to attain.

It took a number of years to solve the problems involved in making and installing such a product as Flexwood. First, veneer cutters had to be able to sample a flitch with a few cuts of 1/28 inch and know whether it would yield flat, uncockled veneer when cut as thin as 1/85 inch. By this time, the subse-

—Photos courtesy U. S. Plywood Corp.

Fig. 1.—Example of figured red gum flexible veneer in a realty office.

Fig. 2.—Teak flexible veneer installed in the office of a theater executive.

quent processing technique had come along to the point where problems of moisture and stress in the fabric or paper backing were well understood. Bonding agents were evaluated to the point where the processor could be certain of producing a flat, limber, and true sheet of genuine wood veneer if he had a well-behaved and flat piece of wood to begin with.

Thus the requirements for veneers became so exacting that many cutters fought the idea of cutting flitches for processing into Flexwood. Fortunately, enough of this country's foremost veneer cutters were sufficiently interested in presenting decorative veneers in their finest beauty form to accept orders with restricting specifications.

Having established the proper type of backing, gotten the veneers as flat as possible, and settled on the type of adhesive and the filler for the cloth and the glue or paste for hanging the product on a plaster wall, it might be assumed that all one had to do was sit back and watch the orders roll in. In the early 1930's, it was true that the orders did roll in. It was also true that the people doing the research forgot to study the subject of plaster. Why would veneer men care much whether plaster had a high or low lime content? Why be concerned much whether the plaster was properly rodded, or soft and scaly?

Many amusing, albeit expensive, things happened in the early days. For example, up in North Dakota a contractor might have applied a perfectly made and conditioned piece of flexible veneer to a plaster wall that was frozen and later, when moisture asserted its inalienable right of escape, back pressure and other technical difficulties caused failure. By the same token, an installation in Texas might suffer because the humidity was such that water would run down a wall before or after the attachment of the veneer decoration. In New York, it was pretty tough to fight the plastering contractors who insisted on doing a cheap, hot lime job.

Today, flexible veneer for attachment to plaster, metal, plywood, hardboard, sheet rock, and other surfaces is readily available on a guaranteed installed basis. A product which always was good is now under full control through all stages of processing, including installation.

The fabric backing commonly used is a 40–44 unsized cotton mesh. Where paper is used, it is unsized and generally .010 inch in thickness. Some people refer to this paper as an "unwoven fabric" but it is a cellulose product.

The processing technique is relatively simple. The select flat veneers

Fig. 3.—Example of walnut flexible veneer in an office building corridor.

are trimmed to eliminate sap and defects and are laid up on the fabric or paper, both of which have been precoated with a polyvinyl alcohol or other flexible type of adhesive. The veneers are book matched and edge joined by being spotted to the adhesive side of the backing sheet with the tip of an ordinary hand iron. Packs of such layups are inserted in a conventional type of hot plate press and the bonding is completed.

After the pressing, the stock, which now measures approximately 18 or 24 inches in width by 8 to 12 feet in length, is put through the flexing machine. In this operation, the cellular unity of the wood veneer is mechanically destroyed. The machine consists of a semi-hard rubber roll about 14 feet long and 24 inches in diameter. The veneer is inserted edgewise into the machine and passes between the rubber roll and stainless steel rods which imbed slightly into the rubber. When the sheet has been put through veneer side up, the operation is reversed and it goes through backing side up.

Actually, the wood stretches as much as ⅜ inch in width in the course of the operation and all rigidity of the veneer and minor fullnesses are eliminated. The elongation of the wood

Fig. 4.—Latest application of flexible veneer is for edge-banding.

fibers across the grain does not produce any splits or checks or cause open areas which would make the paper or fabric backing visible through the veneer. Actually, the wood fibers are parted microscopically so that there is no longer a unity between them.

The next step is the sanding and this is a process that has some unique features. If the production order calls for 100 sheets of walnut, all from one flitch, 18 inches wide by 8 feet long, the 100 pieces are taped together end to end and kept in perfect sequence. Sheet number one starts through the sander and the others follow until the operation is complete. Because of the limpness of the material, the sander is a most ingenious and sensitive piece of equipment. The pressure that holds the veneer against the sanding roll is so sensitive that it compensates for any slight irregularities. Just enough pressure is exerted to keep the veneer in contact with the sanding drum.

After inspection, the sheets are trimmed and packed with their sequence numbers marked on the back of the fabric or paper. The sequence numbering is of great importance because when the veneer is applied to a wall surface, a complete sequence match results if the numbering is followed. If a designer prefers to have a random or mismatched effect, the continuity of the sheets may be broken or certain ones can be reversed and hung upside down.

Installation

For attachment to walls, the fabric-backed material is the only logical choice because there is extensibility to the fabric which permits the stretching of the veneer across the grain to compensate for irregularities in the wall and to assure tight vertical joints.

There are certain problems involved in surfacing metal. Generally, it is recommended that the metal surface be cleaned of all grease or traffic film by washing with Oakite 61. The metal in turn is primed with a material such as Ruscobond F–18. For attachment to plaster and other non-metallic wall surfaces, a varnish-type size is used and the bonding adhesive, both for application to metal and porous type walls, is a latex base adhesive formula supplied by the manufacturer.

Flexible veneer is used mainly for decorating broad wall expanses and particularly those with long sweeping or curved lines. It is essentially a design material and because there are 35 cuts to the inch instead of 28, the continuity of book match, figure, and pattern is great enough to give designers wide opportunity for expression.

There are many outstanding examples of this type. One is the Kleinhans Memorial Building in Buffalo, where 40,000 feet of such beautifully matched material was used. This installation dates back to 1936 and a few years ago it was completely cleaned and refinished. Another is the 42nd Street Branch of the Emigrant Savings Bank in New York done originally in 1932. Since then, additions have been made until now the plaster walls are entirely surfaced with nearly 50,000 feet of Australian lace wood.

Often flexible veneer is the only wood wall treatment possible when building codes ban wood unless it is treated. Plaster walls in auditoriums can be faced with 1/85-inch flexible veneer and will conform to all existing codes. The fact that the walls can be surfaced without the need for moldings means that genuine wood is not to be outlawed as a decorative medium.

Industrial applications for flexible veneer have been comparatively limited, the principal exception being the use of flexible veneer on a special paper backing for the top surface of truwood plastic materials such as Micarta and Formica.

The newest application of flexible wood veneer is a product known as Weldwood Flexible Wood-Trim. This was brought on the market to satisfy the demand for a veneer edge banding that the do-it-yourself addict might use to finish his cabinet work. It now seems likely the product will be employed extensively in commercial woodworking shops. At present, it is available in such woods as mahogany, walnut, oak, birch, Sonora, and fir in 8-foot strips, 1 inch wide.

Measuring Headrig Precision through the Use of Quality Control Charts[1]

DON BURNET
Pilot Rock Lumber Co., Pilot Rock, Ore.

Statistical quality control techniques were used at five sawmills to record the amount and type of variation in lumber manufacturing. Causes of excessive variation were corrected, with resulting marked improvement in size control. Recommendations are given for establishing a system of quality control in lumber manufacturing.

THE TECHNIQUE of quality control through the use of control charts has not been widely used in the lumber industry. For optimum use of raw material, even the rough manufacturing phase must be one of precision. Headsaw precision lends itself readily to the use of statistical quality control charts. The use of control charts in this phase of the manufacturing process will initially determine the capability of the equipment and give visual evidence of any change in that capability. Precision may be gained or maintained by the intelligent application of the necessary control measures indicated by chart data.

The quality control technique as applied here has as its basis that measurements taken from a few randomly selected pieces can give a reflection or estimation of the variation and average thickness of a day's production. The system likewise recognizes that all manufacturing processes, including the sawing of lumber, will vary in some degree from the nominal size being sought. After sufficient measurements have been taken, the variation to be expected for that specific set of equipment can be determined. Thereafter, by keeping the charts up to date, one can tell if the cut is within the normal range of variation and if not, can commence a search for the assignable causes of excessive variation.

Much has been written about the scientific theories and procedures for statistical quality control. It is not the purpose of this paper to enlarge that field of literature, nor to use it in defense of the procedures followed. Rather it is to present the experience gained in the use of the technique under the critical judgment of economic operation, and to analyze the results and reactions from that use.

The work presented here started as a portion of the graduate study program at the School of Forestry, Oregon State College. It was later expanded by the Oregon Forest Products Laboratory.

Statistical Data

The use of a five-board daily sample was an arbitrary decision. Greater sensitivity over a one-board sample is obvious. It was not felt that a greater number would materially increase reliability commensurate with the additional time required for collection of data.

Several methods were used for achieving randomization in the sample. One practice was to take every tenth board on the chain until the sample had been procured. Another was to take each board from a certain position in a stack, as the second from the top on the right hand side, this from enough stacks to supply the sample. A third was to take the required number of boards in numerical order from one side of one stack, such as the top five boards on the left hand tier. The goal in all cases was to insure randomization, to eliminate any possibility of bias in the sample. All of the above methods were effective. The latter two were used at different times to collect the data presented here. Sampling on a time basis is not recommended, as it still leaves a choice for the individual gathering the data.

Measurements were taken with a common steel tape, calibrated to the nearest $\frac{1}{32}$ inch. Each sample board was measured along its length on one side in five places, including each end. Measurements were recorded to the nearest $\frac{1}{32}$ inch. Since the objective was to determine the amount of errant size, plus or minus, the numerical dimension of the board was of no particular concern. Rather what was wanted was the amount in excess of or less than the nominal size to which the piece was to have been cut. Recording in this manner, it was not necessary to take measurements from only one thickness of stock.

For example, one day's sample of five boards might include only 4/4, 4/4 and 8/4, or any other combination. Recorded data indicated only the amount and type of variation from a nominal thickness. The average then has as its reference a zero line, and is related to any optimum size.

[1] Presented at meeting of FPRS Pacific Northwest Section, Oct. 24–25, 1955, in Vancouver, B. C.

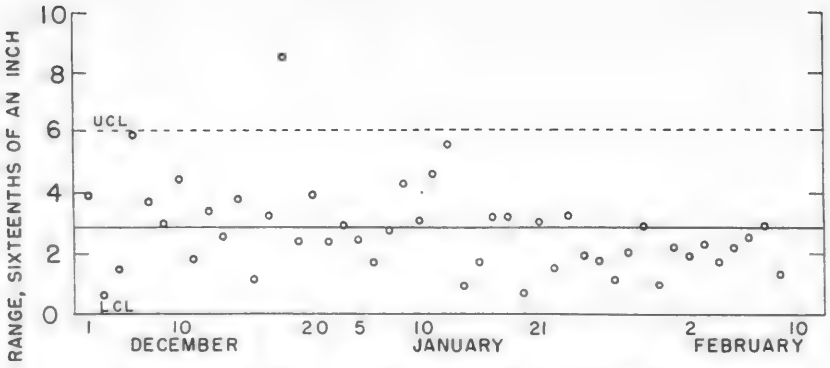


Fig. 1.—Typical range chart of size variation in a circular fir mill.

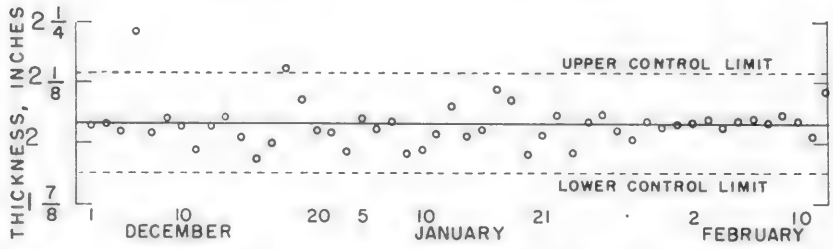


Fig. 2.—Typical thickness chart, showing lack of control initially, followed by close control of size variation.

Another arbitrary decision was the use of data from 20 operating days for the calculation of control limits. It was felt that this was ample time to determine the capacity of the equipment for accurate sawing. Control limits were calculated as outlined by Grant.[2] Limits were calculated for range, being the difference in the averages of the thickest and the thinnest boards for each day, and for the average, the average thickness of the pieces expressed in plus or minus 32's of an inch from the optimum size. According to statistical theory when a plotted point fell outside the control limits, or if seven consecutive points fell on one side of the average, the process was considered out of control. "Out of control" referred to the initial control exercised *during the 20 days on which the limits were based*. One can see from this that we were not establishing a standard to which lumber should be cut, but were measuring the standard of a given set of equipment. The goal was not only to narrow the control limits, but also in most cases, attempt to bring the average down to the optimum size.

Development of the Program

Initial studies were made at two circular mills in the Corvallis, Oregon, area. Both of these mills had been cooperative with the School of Forestry in offering their facilities for class work and observation. At the start of the program there was no participation by the mill other than the use of its facilities.

Data were ultimately collected at five different mills. In addition to the two circular mills in the Douglas-fir region, there was a band mill in the same vicinity, a band mill in the pine region, and one specialty stud mill in the fir region. In all cases, the manner in which the data were collected was the same. Calculation of control limits for both average and range and the construction of the charts was done by laboratory personnel. In the case of the two circular mills and the pine band mill, these charts were turned over to mill personnel for their use, and duplicate records were made available to the laboratory. At the other two mills all collection and analysis of data were done by the laboratory.

Mill Experience

The studies were initiated simultaneously at the two circular mills, called A and B. Both had approximately equal capacity. In both cases, the program was set up and carried on by graduate students before being turned over to the mill.

When sufficient data had been collected to calculate control limits, charts for range and average were constructed and the data transferred to the charts. Thereafter, range and average data were posted from respective daily samples. Figs. 1 and 2 are representative of these initial efforts, each circle representing data from a one-day sample. It can be seen that lack of control may not be evident in both charts on the same day. One might have a high variation which would show the process out of control, but the average thickness could lie well within the established limits. From these charts it seemed evident that when properly taken, sample size was adequate to be sensitive to headsaw variations.

The top management of both mills had been consulted and both were willing to try the system with their own men. Each selected one man to collect the data. These men were given thorough instructions as to the necessity for randomization and the degree of accuracy expected in the measurements.

At mill A a carrier driver and at mill B a millwright became "statisticians". The plan called for the mill to do its own calculations and keep its own charts, which the laboratory furnished along with data sheets.

After a considerable lapse of time, it was found that collection of data had lapsed at mill A. Mill B still had up-to-date data sheets but the control charts had not been used. Laboratory personnel again went into Mill A and collected data for 20 operating days for recalculation of control limits, and the control charts for mill B were brought up-to-date.

Recalculation of control limits for mill A brought out a surprising lack of control, as compared to that first experienced. This is shown in the charts in Figs. 3 and 4. Management was called in for consultation. Its surprise was not hard to imagine.

In Figs. 3 and 4, the control limits shown for April and May are those originally calculated from laboratory data. Those points lying between the arrows (June and July) were computed from data collected by the laboratory for recalculation of control limits. It is evident that some point or points of the manufacturing process were malfunctioning during the time that mill A had neglected to collect and post data. It will also be noted that, had this data been posted, numerous points would have fallen above the original control limits (April and May), and would have indicated to management that a check of equipment was desirable.

After consultation, management did check the process and subsequent recalculation in December indicates the degree of success encountered. The process had returned to a measure of control better than that originally experienced. This incident again convinced us that the technique being practiced was sensitive to the variations of headrig accuracy and could be of value to mill operators.

With the validity of the technique established, it seemed of interest to compare the accuracy of different mills,

[2] Grant, E. L. 1946. Statistical quality control. McGraw-Hill Book Co., Inc., New York and London.

principally the circular mills with a band mill in the same area. Data at the band mill cutting Douglas-fir were collected by graduate students, and calculations made according to methods previously discussed. In the meantime, a band mill cutting pine had become interested in the procedure. They had been provided with the necessary instructions for setting up the system and had gathered data with their own personnel. Figs. 5 and 6 show the graphic comparison of four mills, all cutting Douglas-fir at the time data were collected.

The favorable comparison between circular mill B and band mill C is due, in part, to the use of control charts by mill B for a period of several months preceding test data at mill C. Also, test data at mill C were taken while frozen lumber was being sawn, which resulted in more variation than is normally experienced. The apparent accuracy of the pine mill became a point to question, and a member of the laboratory obtained additional data, which substantiated original data; again, a graphic example of the sensitivity of the technique when properly applied. It might be well to note that the superintendent of the pine mill was vitally interested in use of the technique, and had personally collected the data.

One of the common misunderstandings about the system was that from the charts one could not only tell when something was out of adjustment but also what was out of adjustment. Perhaps this was natural, and perhaps it reflected a poor explanation of what the control charts could do. While it is not possible to specifically identify equipment malfunction from chart data, one can get some indication of the trouble source. If the control charts are in use effectively, and their graphic picture indicates problem areas, more specific location of the areas might be accomplished by retaining the identity of the sample with respect to its position on the carriage, i.e. the top and bottom edge and the entering and trailing edge. This procedure does entail more detailed work. It could be done on a limited basis and need not be incorporated into the regular routine of keeping data. It would be used only when chart data indicated additional information necessary.

Collection of such detailed information was done at a specialty stud mill in southern Oregon. The reason for collecting data as outlined above came about due to the type of operation rather than follow-up of existing charts showing lack of control. The experience does, however, indicate the possibilities of collecting more detailed

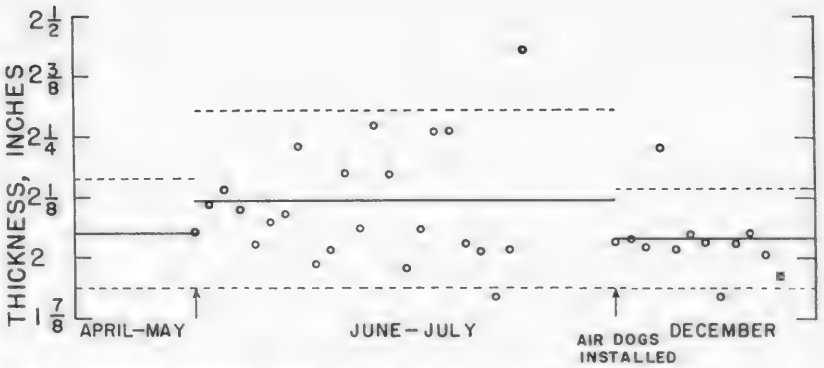


Fig. 3.—Thickness control chart where poor control necessitated recalculation of control limits.

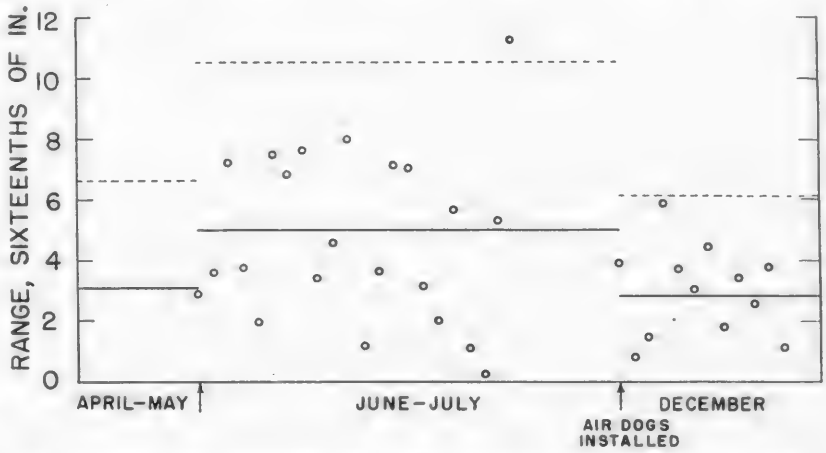


Fig. 4.—Range control chart where poor control necessitated recalculation of control limits.

information to localize specific problems.

This particular mill was cutting old-growth timber. Four-inch slabs were cut on the headrig and turned down to cut 2 x 4 in a gang saw. Since this mill was cutting eight-foot logs, five measurements along one side seemed unnecessary. In lieu of this, measurements were taken at each corner. To give additional information, the identity of the corner was retained, that is, we knew which measurement corresponded to the entering corner, the top front corner, etc. Measuring thus, it was possible to construct range and average charts (really unnecessary) for each corner and from this to actually "see" what was occurring in the equipment. Though this measuring system would not be truly representative of a whole when used on long lumber, it was used in this instance because of the short length and extra thickness of the stock. Analysis of the data at the laboratory indicated certain malfunctions in the carriage. Correspondence subsequently carried on with the mill indicated that what had been deciphered at the laboratory had actually occurred, was corrected, and marked improvement was made in size control!

It has been said that statistical quality control is capable of effecting major gains with operating personnel—if the approach is approximately 90 per cent psychological and 10 per cent scientific. We will not dispute these percentages. We might even be inclined to increase the per cent psychological. The very name itself—statistical quality control—is enough to make the average mill worker tell you to get back to your laboratory and let him get his work done. To combat this feeling, we elected to introduce the technique as "size control", and found the nomenclature more acceptable.

A thorough knowledge of the use of the chart by all associated with it is imperative. A large measure of the sucess of the program is dependent on the quality consciousness instilled in the crew. They must *know* what the system is—that it is an extra pair of eyes and not a device to measure and record production. They must know how it is used and why it is used. At one of the mills that had been using the control charts for a period of almost two years, one worker asked what was the purpose of the measuring! To the answer he replied, ". . . they've been measuring for almost two years and they're cutting worse lumber now than they were before." The charts were not effective in this mill. The case indicates not only lack of

sufficient information on the use and purpose of the system to the crew, but also a lack of application and interpretation of data by management.

It was generally found that when the graduate students or laboratory personnel collected data, the chart was sensitive to the variations of the equipment, but that the average employee, neither thoroughly sold on nor understanding the technique, tended to "select" desirable boards and the charts did not reflect a true picture.

Mill B, with the millwright taking the data, made a fortunate combination of man and job for good use of the technique. The man was interested in the system and was in a position to do something about it when observations so indicated. However, it did have one disadvantage in that he was basing his adjustments on his own interpretation of the data and not from charts, since the charts were kept in the main office and he never saw them. But even that was an improvement over the haphazard "checks" done previously.

Random selection of sample is highly essential to effective use of the control charts. If a thorough understanding is not the lot of the worker, there is a gross effort to overlook those pieces that might reflect poor manufacture. It was our experience that with the poorly informed collecting the data, the process was most always in control. Frequent checks by laboratory personnel during such times often indicated lack of control. When an obviously mismanufactured stick of lumber appeared in the sample it was assumed the chart would look better if it wasn't included. The chart looked better but the lumber didn't change. Operating personnel must know that the control chart is an extra tool in its hand toward gaining a higher degree of precision in manufacturing that assures a better competitive position for the company and hence a more secure job for himself.

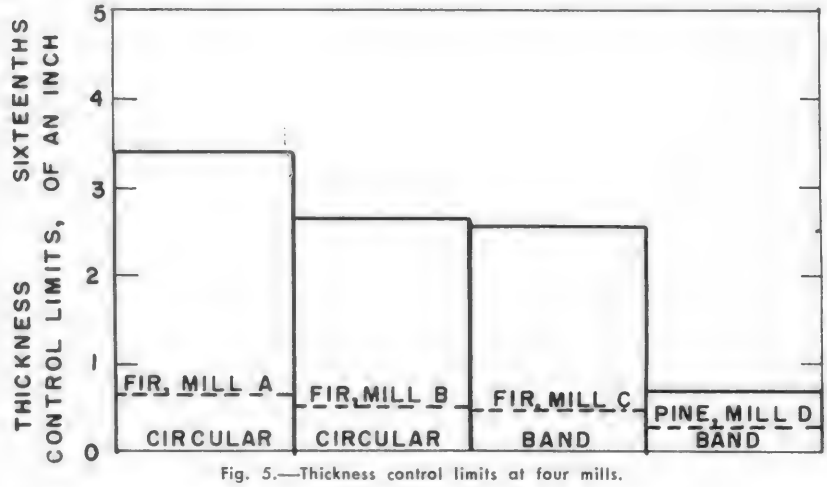


Fig. 5.—Thickness control limits at four mills.

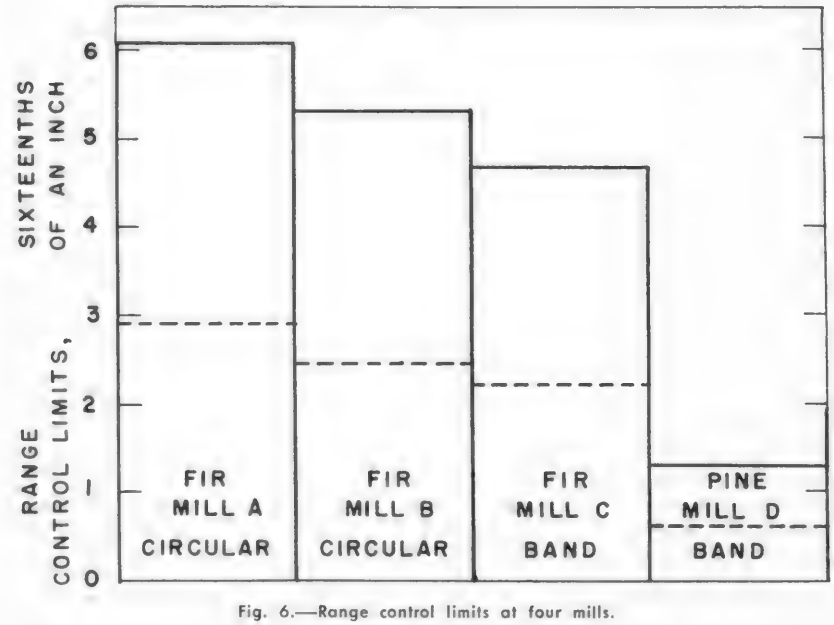


Fig. 6.—Range control limits at four mills.

It was noted in several instances that when conscientious workers took and recorded the measurements, they would attempt to interpret the data from the measurements alone and not post them on the chart. In other cases, the posting of data lagged as much as two months between the time of measuring and the time it was put on the chart. When the posting of data lags even longer than one day, the desired effectiveness of the system is lost.

From experience gained we would recommend the following steps in establishing a system of size control in lumber manufacture:

1. Sell the idea to top management. This does not mean getting their OK to go ahead; it means an enthusiastic approval and an energetic participation in the program.

2. Meet with all supervisors concerned and outline the program in some detail. Assure them that it not only points out the weak points in an operation, but will likewise provide a permanent record of the good jobs and the improvements made. They must understand its purpose and actively participate. They must be convinced enough to use the results after they have been calculated.

3. Meet with the men in the mill. Cover the basic requirements and what accomplishments are expected. Avoid the technical language of statistics. Give them the same assurances given the supervisory personnel. It would be advisable to have top management represented at this meeting to further emphasize management backing.

4. Be critical in picking the men who do the sampling. Insure complete randomization in sampling and insist on accuracy in measuring.

5. Keep the chart current. Post data day by day. Posting last week's data can't solve last week's problems.

6. Note on the chart any major installation, equipment change, or maintenance that might contribute to a change in sawing accuracy.

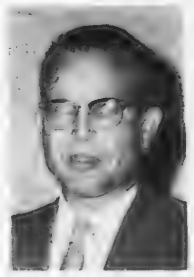
7. Keep the chart posted in the mill. If one is desired in the office, then a duplicate can be kept, but see that the men see it and understand it. If possible, promote inter-shift competition. When the use of the chart is understood and a goal is set, its use should promote quality-consciousness throughout the crew.

8. Rely on the chart. Believe in it. When it shows the process to be out of control, look for probable causes. If you are aware of the causes, correct them. This practice alone will go far in selling management's interest to the crew.

Results of a Re-Logging Experiment in a Selectively Cut Mixed-Conifer Timber Stand[1]

R. D. ROSEBERRY

Chief Forester, Diamond Match Co., Chico, Calif.



Sawmill operators producing pulp chips are revising their merchantability standards. Because of the additional value obtainable from chips, they are starting to bring in logs that would previously have been left behind as culls. This paper describes a study of a re-logging operation to remove such logs and reports green chain lumber recovery as well as bark-free chip yields obtained.

BETTER UTILIZATION of forest resources has long been the desire of timberland owners, loggers, and foresters. This has become more and more important with the increase in value of stumpage. Along with this higher value, it is also fortunate that there is an increased demand for wood fibre.

This over-all picture has made it possible to economically harvest and utilize material that in the past has not been merchantable. This not only includes wood fibre left on the ground but also trees that should have been removed to obtain better growth on the remaining growing stock and help decrease the insect, fire, and disease hazards in the timber stand. In effect, increased utilization increases the volume of the available resources.

With this in mind, the Diamond Match Company decided to make a study of logging shows in their California timber holdings. These timberlands are located in the pine and mixed conifer timber types of the Sierra Nevada Mountains of Northern California. The company was particularly concerned with logs that had been culled and left in the woods due to rot, shake, crook, and merchantability based on both size and value. It also was concerned with trees that should be removed from the timber stand but are not usually marked for cutting due to poor form, low quality, excessive rot, or size limitations, as well as any trees that might have been missed by the timber markers, missed logs by the logging crew, and those trees that die as a result of logging which is ordinarily caused by a temporary build-up of beetles immediately following the woods operations.

All timber harvested on Diamond's California tree farm is marked for cutting by trained foresters. This marking is based on an individual tree selection method. In general, this includes marking the over-mature, mature, and high-risk trees and leaving the younger healthy fast-growing trees up to 4 feet and over in diameter as well as clumps of second growth too small in tree size to properly thin by present utilization standards. Trees are not marked for cutting that will not "pay their way"; they are left for some future time when they will have become merchantable. This avoids felling trees that will not be utilized but also results in leaving an occasional tree in the stand that should be removed for silvicultural reasons.

Minimum utilization standards of the company include logs that are at least 10 ft. long with a 10-inch top diameter inside bark and for pine contain approximately one-third net scale. Fir and incense cedar logs are brought in if one-half sound. These standards vary somewhat with the quality of the log.

Description of Area

For an experiment which was made in 1955, it was decided to re-log an area that had been logged in 1954. This area is located on company land near Butte Meadows. It was felt that results from this area would be representative of old-growth timber lands. The area is considered a good logging show, the soil site I and prior to logging had a good vlume of large old-growth timber as well as dense stands of younger timber. The percentage of rot in the stand was average and the effect of logging was normal. The snags had been felled with the green timber and good utilization was made of the dead material.

Table 1.—COMPARISON OF RE-LOG AND ORIGINAL LOGGING NET VOLUMES

Species	Relogging Bd. Ft.	Original Logging Bd. Ft.	Vol. Av. Log Bd. Ft. Original Logging
Sugar Pine	86,170	1,175,510	1056
Ponderosa Pine	26,430	500,890	994
White Fir	221,680	325,720	853
Douglas Fir		4,590	1148
Incense Cedar	11,780	21,290	519

The area selected contained approximately 60 acres and produced a net volume of 2,028 MBM Scribner decimal C log rule in the original logging.

The re-log for this area gave a net volume. Scribner decimal C log scale, of 346,060 bd. ft. with a species breakdown as shown in Table I. This re-log volume amounted to 17 per cent of the original cut volume.

To designate the logs to have picked-up in this re-log show, one forester marked each log and tree. His instructions were to mark any log that was at least 8 ft. long to a 6-inch top inside bark diameter. This included logs from small trees that were knocked down in the process of logging and building roads, logs that had been culled in the woods and at the landings, chunks, tops, and logs that had been missed by the loggers. The only logs to be left that met the minimum size limits were those that were completely rotten or would not hold together during the process of logging and hauling to the mill.

The main difference in the standards set for log merchantability in the re-log show as compared to the original logging, aside from size, was the value of the log for chippable material as well as for lumber.

Along with the logs, certain trees were designated for cutting. These included trees that should be removed from the stand but were not marked in the original show; those that were unmerchantable, missed, badly damaged in logging and road building, infected with insects and disease; and those in the second growth stand that were high risk or would never make a crop tree due to broken top or other mechanical injury. No attempt was made to thin the clumps of second growth from the standpoint of suppressed trees or to achieve "normal stocking."

Most of the volume that was salvaged came from material not previ-

[1] Presented at meeting of FPRS Northern California Section, April 27, 1956, in San Francisco, Calif.

Author: R. D. Roseberry received B. S. degree from U. of California, was employed many years in timber management and as district ranger with U. S. Forest Service before joining Diamond Match Co. in 1947. He was named chief forester of the firm's California timber operations in 1948.

Table 2.—LUMBER GRADES AT GREEN CHAIN BY SPECIES

A. Sugar Pine—*Pinus lambertiana*

Log Type	No. Logs	Bd. Ft. Scribner Scale: Net Log Scale	Cull	Lbr. Tally	B & Btr.	C Sel.	D Sel.	Green Chain Lumber Recovery Percentage: Mldg.	#1 Shop	#2 Shop	#3 Clr.	4/4 Shop Com.	#2 & Btr. Com.	#3 Com.	#4 Com.	#5 Com.
Immature Timber																
0–50 bd. ft. Log size	241	6,280	200	7,497	---	---	.1	.1	.1	---	---	---	55.7	31.1	11.6	1.3
51+ bd. ft. Log size	187	21,040	3,080	19,414	.4	.5	.9	.8	---	.1	.3	5.9	54.5	26.7	9.6	.3
Old Growth Timber	82	19,440	19,501	20,615	2.2	3.4	8.2	7.5	2.9	2.8	2.3	3.7	1.1	9.7	35.2	21.0
Dead Timber	128	39,410	52,220	35,632	1.8	2.5	6.5	6.1	3.6	3.2	3.6	5.6	3.0	13.4	34.5	16.2

B. Ponderosa Pine—*Pinus ponderosa*

Log Type	No. Logs	Net Log Scale	Cull	Lbr. Tally	B & Btr.	C Sel.	D Sel.	Mldg.	#1 Shop	#2 Shop	#3 Clr.	4/4 Shop Com.	#2 & Btr. Com.	#3 Com.	#4 Com.	#5 Com.
Immature Timber																
0–50 bd. ft. Log size	109	2,700	100	3,193	---	.2	.2	---	---	---	---	---	63.9	22.4	9.5	3.8
51+ bd. ft. Log size	81	8,650	450	8,676	.2	.3	.7	.8	.3	1.8	.4	4.6	45.8	36.6	8.4	.1
Old Growth Timber	21	8,850	6,500	9,265	4.9	5.4	7.7	2.5	3.3	2.6	5.1	7.5	4.9	16.5	27.2	12.4
Dead Timber	15	6,230	6,780	5,778	.9	1.1	4.0	2.5	.7	2.6	1.3	9.6	7.1	17.4	37.0	15.8

C. White Fir—*Abies concolor*

Log Type	No. Logs	Bd. Ft.—Scribner Scale: Net Log Scale	Cull	Lbr. Tally	B & Btr.	C Sel.	D Sel.	Green Chain Lumber Recovery Percentage: Mldg.	#1 Shop	#2 Clr.	#2 & Btr. Com.	#3 Com.	#4 Com.	#5 Com.	#1 Dim.	#2 Dim.	#3 Dim.	#4 Dim.
Immature Timber																		
0–50 bd. ft. Log Size	450	11,240	570	13,310	---	---	---	---	---	---	9.2	4.0	2.8	.7	43.5	24.3	10.3	5.2
51+ bd. ft. Log Size	602	95,060	6,320	91,357	.2	.4	1.3	.8	---	---	4.4	2.3	1.2	.2	52.5	22.2	9.6	4.9
Old Growth Timber	179	95,780	37,460	88,569	1.5	1.9	5.0	3.6	.2	.1	.6	1.3	1.3	.3	27.0	25.1	19.1	13.0
Dead Timber	68	19,600	28,660	15,602	.1	.4	.4	.3	---		.9	1.9	6.4	20.5	22.7	24.0	11.4	11.4

D. Incense Cedar—*Libocedrus decurrens*

Log Type	No. Logs	Bd. Ft. –Scribner Scale: Net Log Scale	Cull	Lbr. Tally	C Sel.	D Sel.	Green Chain Lumber Recovery Percentage: Mldg.	#2 & Btr. Com.	#3 Com.	#4 Com.	#5 Com.	#1 Dim.
Immature Timber												
0–50 bd. ft. Log Size	177	4,260	50	4,815	---	---	---	55.7	27.5	16.3	.5	
51 + bd. ft. Log Size	81	7,520	180	7,691	.1	.8	1.8	41.8	35.7	18.0	1.6	.2

ously utilized due to size and from logs previously culled due to defect. Also cut were three small trees that were infested with insects at the time of relogging and one tree that was missed by the timber markers.

Outline of Study

The method of handling this study in the mill was to have one forester grade, scale, measure length and the diameter of both ends, obtain a net scale for lumber, and note the type of rot in each log. The logs were also numbered. One man spotted immediately behind the band saw numbered each board corresponding to the number of the log from which it came. Two different colors of crayon were used in order to change colors in the numbering of the boards as the logs changed on the carriage.

Two lumber grader-tally men on the green chain recorded grade, size, and board footage of each board. The boards were tallied by number to correspond to the number of the log.

The results of this study showing lumber grades at the green chain by species are shown in Table 2.

The volume of Douglas-fir was so small that these results are not included in this report.

Conclusions

The results of this re-log experiment definitely indicated the necessity of considering this type of operation in the future. Although the experiment was only carried through to the green chain with the use of both woods and mill equipment built for large timber, it certainly gave a good idea of volumes and values of forest products involved in this type of operation.

Due to the type of equipment used the costs of this study are not indicative of such an operation employing the proper type of equipment so cost information is not included in this report. With the use of proper equipment in both the woods and mill, there is a definite value in the smaller logs. The value of this small high common type of log not only permits better utilization within logged-over areas but also opens up the possibility of properly thinning second-growth timber stands with a reasonably high degree of utilization.

Table 3.—BARK-FREE CHIP YIELD

Log Size Group	Species	Log Grade	Units of Chips Per MBM Net Scale
20 BF & Less	Pine	High Common	1.24
	Fir	High Common	1.11
	Cedar	High Common	1.18
21 to 50 BF	Pine	High Common	.86
	Fir	High Common	.98
	Cedar	High Common	.99
51 to 200 BF	Pine	High Common	.55
	Fir	High Common	.57
	Fir	Low Common	.62
	Cedar	High Common	.40
Average (Logs less than 200 BF net scale)			.66
Over 200 BF	Fir	High Common	.36

Note: 1 Unit = 200 cubic feet of chips.

The results of the experiment as a whole seem to be logical with a few exceptions. We would normally expect a substantial over-run on the smaller logs in the 51 board feet and over class in immature timber. This class showed an under-run in these results. Also, the values in the old-growth pine logs salvaged are mis-leading as they contained a few merchantable logs and one high-grade tree missed in the previous logging. While a few low value old-growth fir trees were purposely left standing in 1954, some of them showed a positive value on the higher fir market of 1955.

In addition to the monetary values obtained in re-logging, there are also other definite advantages to this type of operation. A real value in the removal of this salvage material from the woods is in the protection of the reserve timber. This re-log operation substantially reduced the fire hazard, decreased infection centers for disease and breeding grounds for destructive insects. Thinning over-crowded second growth stands will also increase the annual net growth. From an operational stand point it is possible to increase efficiency of the logging by having the large sides handle the larger timber leaving the smaller material for a re-log side.

Around the World in Forest Products Research and Development

Australian Lab Develops Treating Method

A simple diffusion process for the preservative treatment of green building timbers has been developed by the Division of Forest Products, C.S.I.R.O., Melbourne, Australia. The process has been applied successfully to the treatment of klinki pine for the construction of 50 houses in New Guinea.

The new method applies to green sawn timber of scantling size the simple and successful method of treating green veneer which was developed by the same division in 1949. This veneer treatment consists of a momentary dip in a cold solution of boric acid or borax, followed by block stacking the wet sheets for a few hours to permit diffusion of chemical into the wood before drying. The process is now used commercially in many Australian plywood plants.

In developing the process for application to sawn timber, the main requirements were: to formulate a preservative which would dissolve readily in water to give a highly concentrated cold solution, so that green timber of scantling size would retain enough preservative on the surface following momentary dip for subsequent diffusion to a depth of at least one-half inch; to retain boron compounds in the basic formula but to be able to add other preservatives, including an arsenical compound, particularly where increased resistance to decay or termites was required; and to determine the practicability of preventing drying during the block stacking periods of several weeks necessary for deep diffusion into the wood.

The basic preservative formula contains a boron and a fluorine compound in proportions which permit greatly enhanced solubility of both compounds, due to the formation of highly soluble borofluorides and pentaborates. Where control of *Lyctus* and *Anobium* borers is required, this basic formula may be used without additives, as it will retain more than 30 per cent boric acid equivalent in cold solution (w/w basis).

For most purposes the addition of an arsenic and a chromium compound is recommended to increase toxicity and to increase the total quantity of preservative in solution. The formula containing all four compounds will retain over 80 per cent of salts in solution at room temperature, and is suitable for the dip diffusion treatment of large section timbers.

Timber treated by the above process should not be used in contact with the ground, or where frequent leaching is likely to occur, unless a second diffusion treatment with a copper or other heavy metal salt is given to fix the preservatives in the wood. The single treatment is, however, very suitable for protected building timbers, including painted weatherboards, where it should remain permanently effective.

—C.S.I.R.O. Forest Products Newsletter

Scanning World-Wide Forest Products Publications

Japan

Studies on the Cause and Control of End Waviness and Split during Drying of Veneer. T. TUTUMOTO. Journal of Japan Wood Research Society, Vol. 2, No. 2.

End waviness and split during drying of veneer are thought to occur by faster drying at the end part of veneer. Effective means to prevent such defects are, controlling moisture evaporation or reducing tensile stress at the end part.

Several methods were applied on practical dryer process and the following pretreatments were found to be effective compared with other methods:

1. Pasting on one surface of the end part a piece of kraft paper of 30 mm width.
2. Wrapping the end part with polyethylene-coated kraft paper in 15 mm. width.
3. Cutting and patching of the end part at intervals of 50 mm.

Norway

Actual Problems within Forestry and Forest Industry. O. T. Jarlsby, Norwegian Pulp and Paper Research Institute, Vinderen, Oslo.

Data are presented concerning possibilities of further development in pulp and paper industry and other forest industries in view of the world market expansion. With regard to mechanical and chemical pulp for application in the production of paper, the demand follows closely the development of paper consumption. On the whole, world consumption has doubled from the pre-war years, amounting today in excess of 50 million tons annually.

A joint investigation made by FAO and ECE (Economical Commission for Europe) reveals that world paper consumption will be doubled every thirty years. The question arises as to how much of this increase the Norwegian pulp and paper industry may be able to cope with in the future, as developments depend on various conditions.

The author's opinion is that the future of the Norwegian pulp and paper industry depends on the international trade policy. No matter what the development may be, however, the future is expected to provide means of disposing of products and domestic raw material. At present, the industry takes all the timber and pulpwood the Norwegian forests can supply and some import of pulpwood has been necessary.

An Apparatus for Measuring the Setting of Sawblades in Proper Position on a Sash Gang Saw. F. B. Nielsen. Norsk Skogindustri, Vol. 11, No. 2.

In order to keep the sawblades in proper position on a sash gang saw, most of the sawmills make use of wood guide gauges. Since these are made or sawn by hand the accuracy obtained is limited. Wood gauges also easily change dimensions according to moisture content in the air and force applied on the gauges in the sash when setting the sawblades. It is the author's opinion that gauges made of a stable material will increase sawing accuracy and give smaller kerf widths. When setting the sawblades the sawyer uses quite primitive and simple tools, and accuracy of setting up is mostly dependent on the skill and experience of the sawyer.

In 1956 some tests were made with wood gauges made by hand and machined gauges made of bakelite bearing material. In addition, a new design of an apparatus for measuring accuracy of the setting was used and proved very useful. The tests showed that the deviation of the sawblades from thin nominal positions in the set was about twice as big when using wood gauges as when using bakelite gauges.

Abstracts From Current World Literature

Milling

Moon, R. Pulpwood billet production in Boyer woodmill. Australian Pulp & Paper Ind., Tech. Assoc. Proc. 9:31–46; discussion: 46–8 (1955).

The plant and plant operations of the Australian Newsprint Mills Ltd., Boyer, Tas. are described, with special reference to the functions of various saws and other equipment. Problems arising from sawing hard eucalypt wood are discussed, and the importance of the basic density of the timber in selecting suitable sawing machinery is emphasized. Other items treated in detail include log and billet handling and the disposal of rejects and sawdust. [Bul. Pap. Chem. V. 27, No. 1]

Entomology

Anon. Forest insects. J. Agr. Food Chem. 4, no. 8:666–7 (Aug., 1956).

Both Western and Southern forests are plagued by insect pests to the extent that damage to southern pine and hardwood saw-timber will exceed 1.5 billion board feet this year in spite of increased chemical control measures. Insects, damage figures, costs of control by insecticidal sprays, and co-operative efforts made to ease the critical situation are discussed. [Bul. Pap. Chem. V. 27. No. 1]

Chemical Utilization

Meller, A. The actual and potential degradation of cellulose fibres. Australian Pulp & Paper Ind., Tech. Assoc. Proc. 9: 192–206; discussion: 207–8 (1955).

An attempt has been made to clarify the terms "degradation," "over-cooking," and "overbleaching" of cellulose fibers. The relative nature of these terms in two respects is discussed. The hydrolytic degradation of the cellulose molecule can be defined more precisely. Hydrolytically degraded cellulose fibers are "actually" degraded; so far this degradation has not been reversed. In contrast, "potential" degradation involves an oxidation of some of the functional hydroxyl groups to carbonyls of the glucose or pentose units of the polymeric carbohydrate molecules of wood pulps. Such changes do not shorten these molecules but render them vulnerable to attack by alkaline or acid solutions. Examples are quoted showing the importance of these degradations in the processing of cellulose fibers in the textile and wood-pulp industries. It is also shown that "potential" degradation can be remedied to a large extent. [Bul. Pap. Chem. V. 27, No. 1]

Mensuration

Prielipp, D. O. Balsam fir tree volume in the Lake States. Forest Sci. 2, no. 2:92–9 (June, 1956).

The volumes of 476 balsam fir trees were determined to give information on the effect of soil site and on the relative effectiveness of two newly developed methods of volume-table construction. The study indicated that there is a significant difference in the volume of large trees growing under different soil-moisture conditions. For a given diameter and height (10 inches or larger d.b.h.), the volume was about 10% greater in swamp trees than in transition and upland stems. This difference and the lack of a good balsam fir volume table make the construction of new volume tables desirable. Two such tables, constructed by the combined-variable graphic method, are presented. This method is faster, easier to comprehend, and better suited for small groups of data than is the revised harmonized-curve method and yields equally good results. [Bul. Pap. Chem. V. 27, No. 1]

Pathology

Anon. Gibberellins for growth. Chem. Eng. News 34, no. 38:4496, 4501 (Sept. 17, 1956).

Increased linear growth of plants and trees is reported to be effected by treatment with gibberellins, substances produced by *Gibberella fujikuroi*, an organism which causes the elongation of rice shoots. So far, three chemically different compounds have been isolated and empirically identified through efforts of Japanese, English, and American research workers. New growth of young forest trees such as willow oak, tulip-poplar, and maple was greatly increased by treatment with gibberellic acid. [Bul. Pap. Chem. V. 27, No. 2]

Fire Prevention

Spontaneous heating and ignition in sawdust heaps. P. C. Bowes (D.S.I.R. and Joint Fire Research Organization). *Wood*, Vol. 21, No. 1, January 1956.

No precise recommendations can be made for the prevention of spontaneous ignition in large sawdust heaps, the best guide to the risks involved being a study of existing heaps, if any, in the same locality. If it is being piled for the first time in a given locality, or if a larger heap than hitherto is planned, a careful watch should be kept on the first 50,000 cu. ft. or so, and the height restricted initially.

Temperatures, determined, say by inserting thermometers into iron pipes which are driven into the heap over the surface and to varying depths, should be recorded until it is quite clear that the stack is cooling. Heaps should be built in a series of shallow layers of a large area with each layer compacted before the next is added and any coarse waste included well mixed with the sawdust. A layer of earth over a completed heap would possibly reduce the risk of ignition by restricting the air supply to the interior of the heap.

Experience has indicated that, should a fire break out in a heap, steam injection is more effective than water for controlling the fire. [F.D.C. Tech. Bul. V. 6, No. 32]

Properties

Stone, J. E. The penetrability of wood. Pulp Paper Mag. Can. 57, No. 7: 139–45 (June, 1956).

Wood varies in its ease of penetration over a wide range, depending on species and whether it is sapwood or heartwood. Obtaining adequate liquor movement into woods widely differing in permeability poses two separate problems of different orders of magnitude which may require different methods of attack. Only by knowing the actual permeability of the wood being studied can a penetration problem be seen in proper perspective and the results obtained related to the data of other investigators on a different wood species. A simple method of measuring wood permeability is given. A suggested useful form for recording permeabilities is the fourth power of the radius of a single theoretical capillary which would give the same rate of the flow as all the capillaries in one sq. cm. cross section of the wood. A number of pulpwoods have been so rated, and their penetration factors listed. A discussion is given of the tyloses which are largely responsible for poor penetration in many deciduous woods. [Bul. Pap. Chem. V. 26, No. 12]

Mushabarara (Drypetes sp. aff. D. battiscombi). Uganda Forest Department Leaflet No. 26.

Mushabarara, which grows in Uganda and occasionally in Buganda, comes from a tree with a very straight but fluted bole often containing 50 ft. of convertible timber.

The wood is white when first cut, darkening a little after long exposure with no visible difference between heartwood and sapwood. The grain is fairly straight and the texture fine and silky. Average weight at 15% m.c. is 45 lb. per cu. ft. Its strength properties are similar to Iroko. It seasons slowly with little warping or splitting. It is not durable and is liable to staining and fungal attack.

The timber works easily but support when boring or mortising, and pre-boring before screwing is necessary. It will take a good lacquer finish if pre-filled. It is rather plain but a good utility timber for joinery or structural parts of furniture. [F.D.C. Tech. Bul. V. 6, No. 32]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

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CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

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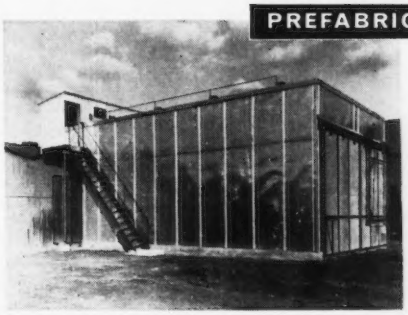

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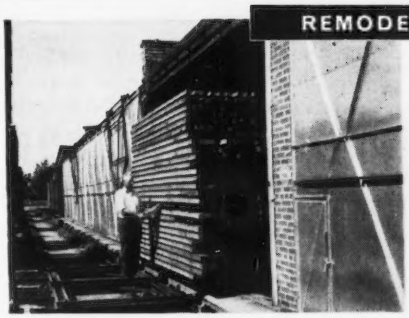

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Review of FPRS Section Meeting Papers

Preventing Wood Deterioration in Modern Southern Housing

W. B. Clements, President, Florida Pest Control Association, Leesburg, Fla. Florida–Georgia–Alabama Section Meeting, Nov. 18–19, 1955, in Gainesville, Fla.

The problem of protection of southern homes from decay and insect attack is three-fold. It involves making available to the public wood products that are treated to give protection against the entrance of insects and decay, education of architects and building contractors in the proper use of such materials, and public education.

A forward step is the increase in the use of lumber that has been treated to resist decay and insect attack. Some evidence of treatment can be seen in practically every building under construction. The comparatively recent availability of window and door frames which have been pretreated is another definite step forward.

The primary approach should be one of education of not only the public but the architect and builder to bring about the development of proper building procedures. One obvious avenue of approach is through the architects and architectural schools but such procedure, even if entirely successful, would scarcely touch the general building trade. There is no way to really reach all building contractors, with new ones developing every year in every community. Thus it appears that the best approach is through the general public. Some progress has been made but much more work is needed before there will be adoption of good building practices on a large scale.

An extensive program of advertising and public relations is needed on possibilities of resisting decay and insect damage through use of treated lumber, proper building procedures, and the use of building materials manufactured and designed for conditions prevalent in certain areas.

Lu-Re-Co: The Lumber Dealer's Answer to Better Low Cost Housing

F. L. Dill, Dain and Dill, Inc., Carmel, N. Y. Northeast Section Meeting, Oct. 25–26, 1956, in New York City.

The Lumber Dealers Research Council, formed in 1949, has made studies of marketing, pricing, windows, closet walls, and house planning. The development of the Lu-Re-Co construction system, however, has brought the widest recognition to the Council.

The University of Illinois Small Homes Council was commissioned to develop a construction system that utilized stock lumber yard material, could be done in the average lumber yard, and was flexible in design. After studying both conventional and prefabricated building, the Lu-Re-Co system was developed to incorporate the best features of both methods.

Franchises for the system are sold to any recognized lumber dealer in the U. S. and Canada, with more than 1,000 already franchised. It is estimated that more than 10,000 houses are being built annually under this system.

Dealers can make up all sidewall panels, interior panels, and floor panels in one jig and roof trusses in another. The floor and interior panels have not been extensively used, however, because the conventional method is still almost as economical.

Principal use of the system has been for 4- by 8-foot exterior panels. These are made in a steel jig on a 5- by 9-foot plywood table. Studs 2 by 4 inches are spaced usually on 24-inch centers, with plywood, insulated, gypsum, or tongue and groove sheathing. Two-foot panels can also be made in the same jig. The panels can be made up solid and as window and door panels. If desired, the windows can be placed in the panels in the jig.

One of the best features is the 2- by 6-inch double header that is placed above the panels. This is usually made up in advance and consists of two pieces of 2 by 6's and a $\frac{3}{8}$-inch plywood spacer. A 4-foot overlap is necessary when the two pieces are joined on the top. A $\frac{3}{8}$ by 7-inch lag bolt is placed in every panel between the two pieces of 2 by 6's and screwed down to the panels. This ties all the panels together, gives even distribution and makes it unnecessary to use any small 2 by 4-inch bracing above the windows and doors.

Use of roof trusses makes possible open-room construction so that flooring can be laid throughout the house before partitions are erected. Because bearing partitions are not needed, smaller sized partitions can be used. The modular inside dimensions facilitate use of stock sizes of wallboard with little cutting. Most lumber dealers are combining the Lu-Re-Co panel and truss with as many component parts as possible, including "redihung" interior doors, kitchen cabinets, prefinished flooring, and prefit chimneys.

It is estimated that use of the panels and trusses saves about 200 man-hours of labor on the average house. It also gives the dealer an opportunity to offer a house that is easily constructed, can be made locally, and can compete with any prefab brought in from the outside. The system gives the small contractor a packaged house which enables him to compete with large project builders.

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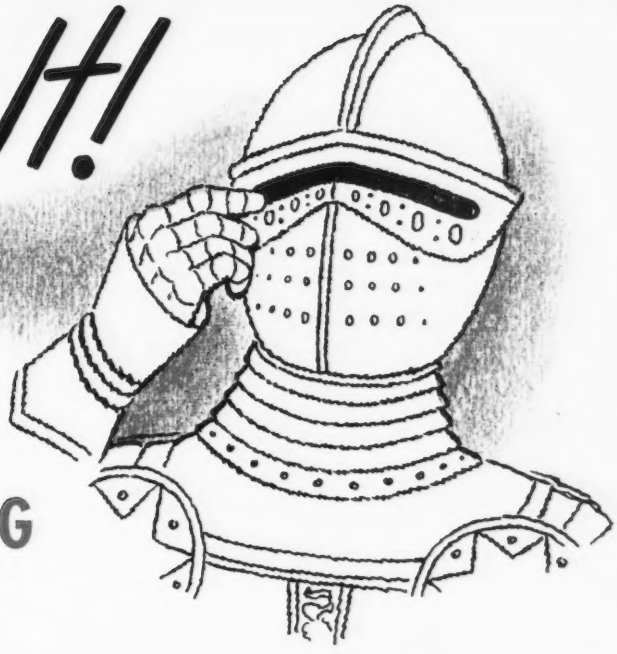

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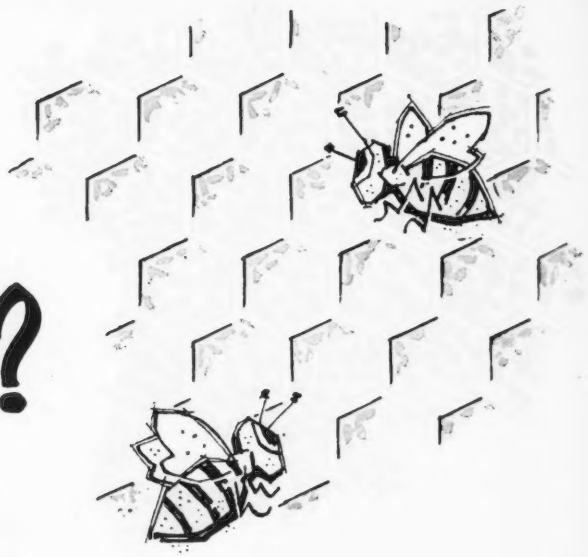

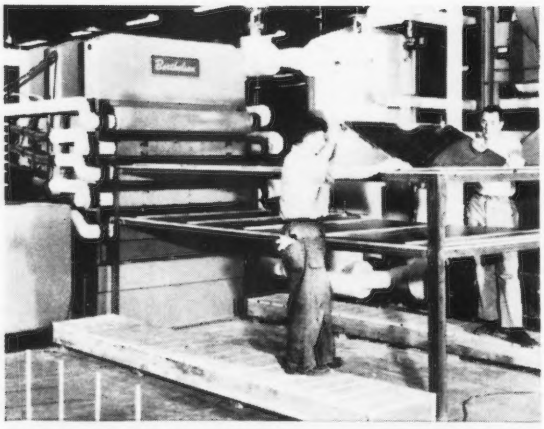

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